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RESOURCE RECOVERY AND SOURCE REDUCTION

SECOND REPORT TO CONGRESS

ENVIRONMENTAL PROTECTION AGENCY

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SECOND REPORT TO CONGRESS
RESOURCE RECOVERY AND SOURCE REDUCTION

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U.S. ENVIRONMENTAL PROTECTION AGENCY
1974

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FOREWORD

The Solid Waste Disposal Act (P.L. 89-272, Title II, Section 205) requires that the U.S. Environmental Protection Agency (EPA) study the recovery of resources from solid waste and the reduction of solid waste at the source. This document represents the Agency's second report to the President and the Congress on these subjects.

The first EPA report, issued February 22, 1973, discussed the environmental benefits of recycling, identified the technical and economic factors that appeared to impede recovery of waste, and outlined the major options available to increase resource recovery or reduce the generation of waste. Program activities to analyze and evaluate these options were described. This second report presents the findings of EPA's studies to date.

The information contained in this report was derived from a number of contractual efforts, demonstration grants, and in-house analyses. The Agency staff members who made major contributions to the development and preparation of this report are John H. Skinner, Stephen A. Lingle, Eileen L. Claussen, Frank A. Smith, Arsen J. Darnay, J. Nicholas Humber, Laurence B. McEwen, Michael Loube, and Fred L. Smith.

–RUSSELL E. TRAIN
Administrator
U.S. Environmental Protection Agency

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SUMMARY

This report presents a review of EPA's studies and investigations for the year 1973 on the subjects of resource recovery (i.e., the utilization of material, energy, and products recovered from solid waste) and source reduction (i.e., the reduction in the generation of waste through a reduction in material or product consumption). The objective of this report is to present the various resource recovery and source reduction programs that EPA has studied and to discuss results related to conservation of energy and material resources, protection of the quality of the physical environment, and economic effects. EPA expects that this report will be useful to interests outside the Federal Government, including State and local governments, private citizens, industry, the academic community, and private consulting groups.

This report examines the many and diverse issues associated with this field. Its five chapters discuss (1) projected trends in resource utilization, environmental pollution, and solid waste generation that give impetus to consideration of resource recovery and source reduction measures; (2) the effects of several existing Federal policies and programs on the level of use of virgin and recycled materials; (3) resource recovery systems and the markets for materials and energy recovered from post-consumer residential and commercial waste; (4) product controls, such as bans, standards, charges and deposits, directed at regulating the design or consumption of products for resource recovery or source reduction purposes; (5) studies of resource recovery and source reduction of several special wastes: automobiles, packaging, beverage containers, and rubber tires. A summary of key findings in these areas follows.

RESOURCE CONSERVATION, ENVIRONMENTAL, AND SOLID WASTE MANAGEMENT ISSUES

- Continuation of historical growth rates of production and consumption will maintain demands on raw material and energy supplies and will lead to the generation of increased quantities of solid waste.
- There exist a number of areas of considerable uncertainty and risk regarding future resource supplies. These include the extent of mineral discoveries and the costs of exploiting them, future growth rates of world market demands, and the impact of geopolitical events on international resource markets.
- Future material supply efforts could place burdens on the physical environment. The levels of atmospheric emissions and effluent discharges could increase and large-scale surface mining and forest cutting operations could cause detrimental effects.
- Increased solid waste generation rates could involve higher waste management costs, greater land disposal requirements, and environmental risks attendant to waste collection, processing, and disposal.

- The energy potentially recoverable from post-consumer residential and commercial solid waste (equivalent to 400,000 to 500,000 barrels of oil a day) could supply roughly 1 percent of the Nation's current energy demand. Materials recycled from post-consumer solid waste could provide 7 percent of the iron, 8 percent of the aluminum, 20 percent of the tin, and 14 percent of the paper consumed annually in the United States. While these percents represent the practical potential for resource recovery to provide new energy and material supplies, actual recovery levels will be constrained by technical, economic, and institutional factors.

- Resource recovery and source reduction have the potential of achieving reductions in the cost of solid waste disposal. Source reduction would also effect waste collection cost savings.

- Utilization of recycled material rather than virgin material generally results in reduced levels of atmospheric emissions, reduced effluent discharges to natural waters, and reduced generation of industrial and mining wastes when all stages of material acquisition, processing, and transportation are considered. In addition, recycling is typically much less energy intensive than virgin material production.

- Source reduction is believed to result in a reduction of the negative environmental impacts associated with the production of materials and products and the generation of waste.

- While resource recovery and source reduction offer potential for conservation of resources and improvement of environmental quality, the mechanisms through which they could be accomplished should be evaluated from the standpoint of economic feasibility and efficiency.

- The economics of resource recovery and source reduction may be expected to improve for several reasons: land disposal and incineration costs may be expected to rise as more environmentally sound practices are adopted, costs of production from virgin materials may be expected to increase because of pollution control and other costs, and rising costs of energy production by conventional means may stimulate greater use of solid waste as an energy source.

EXISTING FEDERAL POLICIES AND THEIR EFFECT ON VIRGIN AND SECONDARY MATERIAL USE

Freight Rate Policies

- There is evidence to indicate that the current freight rates for some recycled materials are high relative to rates for competing virgin materials (rail rates for scrap iron, glass cullet, and reclaimed rubber and ocean rates for wastepaper). Rates for these recycled materials exceed transport costs by a higher percent than the rates for virgin materials.

- While it is difficult to predict the degree to which a rate increase would result in lower levels of recycling, there is evidence to indicate that freight rates represent a significant fraction of the cost of using many recycled materials (scrap iron, wastepaper, glass cullet, and scrap rubber).

- It is recommended that the transportation regulatory agencies, in consultation with EPA, conduct a study of rate-setting practices for all recycled materials shipped by rail and ocean carriers to determine the extent to which discrimination exists against recycled materials.

- It is recommended that in all future proceedings in which rates for recycled materials are adjusted, a specific finding be required that such rates do not discriminate against recycled materials.

Federal Procurement Policies

- Although the Federal Government is the single largest consumer of many products, Federal procurements generally represent a small fraction of national material markets. Therefore, the direct market creation effects of a program of Federal procurement of recycled products would probably be small. However, because Federal procurement specifications are widely circulated and duplicated by State and local governments and some industries, such a program is desirable to provide national leadership in this area.
- It is recommended that EPA, in conjunction with the Federal supply agencies, develop guidelines for the inclusion of recycled materials to the maximum extent practicable in products purchased by the Federal Government.

Taxation Policies

- Various provisions of the Federal tax code (depletion allowance, capital gains treatment, and foreign tax credits) provide substantial benefits to the virgin material production sectors that are not available to the recycled material sectors. (These benefits are estimated to be more than $200 million annually for the virgin mineral and timber production segments.)
- It is difficult to estimate the quantitative impact of these tax provisions on material use; however, they do provide opportunity for expansion and investment in the virgin material sector. To the degree that these benefits reduce virgin material prices, they could result in overconsumption of virgin resources and act to inhibit the use of recycled materials. To be consistent with the national goals of conserving energy and material resources, it is recommended that consideration be given to reevaluation of these tax provisions.

RECOVERY OF RESOURCES FROM POST-CONSUMER SOLID WASTE

- Municipal waste recovery is emerging as an economic alternative to traditional forms of solid waste processing, especially in areas where disposal costs are high and adequate markets exist for recovered commodities. As energy, material, and disposal costs continue to rise, the economics of resource recovery will become even more attractive.
- There are a number of technical systems available today for the recovery of material and energy from solid waste. In the 1975-76 time frame, several additional technical options will be in full-scale demonstration operation and will widen the available technical choices and range of products that could be obtained from wastes.
- Energy recovery—especially the use of shredded waste as a utility fuel—appears to be an economical near-term recovery option. Energy recovery is usually accompanied by metal and glass recovery as well.
- Paper recovery through separation at the source and separate collection of wastepaper grades such as old newspapers and corrugated paper is an economically feasible form of resource recovery that is being practiced in many communities today. Technological systems for extraction of fiber from mixed municipal refuse are under development.

- There are several markets for steel cans, which can be separated magnetically from mixed municipal waste. These markets include the steel industry, copper precipitation industry, and the detinning industry. Detinning of steel cans results in a high-grade steel scrap and also recovers another valuable resource—tin. Aluminum contamination of steel can scrap increases the costs of detinning.

- The major barriers to aluminum and glass recycling are related to the economic extraction of these materials from mixed municipal waste. Once extracted, there appears to be sufficient demand to facilitate significant increases in recycling of these materials. Technology is under development for aluminum and glass recovery but has not proven to be economically feasible to date.

- While systems for separation of plastics from mixed municipal waste for recycling are not available, plastics could be recovered as energy. However, combustion of polyvinyl chloride plastic fractions could result in increased costs and potential air and water pollution problems.

- A number of States and communities are pursuing implementation of recovery systems. More than six States are actively planning programs to promote waste recycling. Three of these States have or will soon have funding programs to support community facility construction, and two additional States are known to be considering some type of statewide resource recovery activity. A number of municipalities are moving forward with their own plans to install systems, some with State support, some with their own financing, and some with private developer financing to be repaid in the form of service charges. Eighteen cities have been identified as actively pursuing establishment of a resource recovery facility. In these cities either construction has begun, a design contract has been awarded, or the city is firmly committed to proceed. At least 20 additional cities are known to be at the preliminary investigation stage. More than 70 cities currently operate separate collection systems for newspapers, up from a handful 2 years ago.

- Capital markets appear to be capable of supplying funds needed for municipal resource recovery expenditures. However, some methods of obtaining financing are not well understood or used on a wide scale by municipal authorities. In addition to the traditional general obligation bonds, other sources of financing include revenue bonds, bank loans, leasing, industrial revenue bonds, public authority financing, and State grants.

- While recovery system implementation is proceeding, some institutional and marketing problems exist that will impede or slow down developments. Federal technical assistance/technology transfer to aid in the implementation of recovery systems is being provided. In addition, an applied research and development activity at the Federal level is being undertaken to improve current systems, to upgrade products from recovery plants, and to assess the environmental consequences of recovery systems.

- Studies indicate that fiscal incentives to stimulate the demand for recycled materials are not necessary at this time. For many recycled materials, demand is currently high, prices are up, and supply shortages have occurred. In the future, however, the historic problem of inadequate demand for recycled materials may return. As a result, demand incentives may become desirable.

There are considerable uncertainties in this volatile market area, and the demand situation should be carefully analyzed and monitored in the future.

PRODUCT CONTROLS FOR SOURCE REDUCTION AND RESOURCE RECOVERY

- The theoretical justification for product controls for resource recovery or source reduction purposes is based on the supposed failure of private market decisions to evolve socially optimal product designs including consideration of factors such as product durability, repairability, ease of material recovery, or waste disposal costs. Little or no economic analysis exists on the subject of the social efficiency of product design; however, general observation of product design from a resource conservation, waste disposal, or recovery perspective provides evidence of the need for further study of product control possibilities. Possible product controls for source reduction could include regulation of product lifetime, reusability, consumption level, and material or energy intensivity. Control mechanisms include taxes or charges, deposits, bans, and design regulation. Possible product controls for resource recovery could include regulation of reclaimability and recycled material content.
- Although there could be resource conservation and environmental benefits from various product control approaches, these measures could also have negative impacts on the market system and result in economic dislocations. At present, there is insufficient information to evaluate the necessity or desirability of product control measures.
- It is recommended that EPA continue to study and evaluate product controls in an attempt to identify measures that would lead to increased overall efficiency of resource utilization, pollution control, and waste management. Several studies in this direction are currently underway.

STUDIES OF RESOURCE RECOVERY AND SOURCE REDUCTION OF SPECIAL WASTES

Obsolete Automobiles

- Strategies for dealing with abandoned automobiles involve preventing abandonment and arranging for the collection and shipment of derelict vehicles to scrap processors. Innovative measures (e.g., deposits, bounties, and registration certification) have been suggested and tried to implement these strategies; none has been used on a large scale.
- Continued recycling of obsolete automobiles depends in part upon continued high prices for steel scrap. Changes in automobile design (e.g., lighter automobiles and substitution of plastics and aluminum for steel) and changes in steelmaking technology could also reduce the price of automobile scrap and impede recycling.

Packaging Wastes

- Packaging wastes represent the single largest product class in the municipal waste stream (34 percent by weight), and the consumption of packaging material is growing at an accelerated rate (on a per capita basis, packaging material consumption was 412 pounds in 1958 and 621 pounds in 1971, a growth rate of 51 percent per capita in 13 years). This trend has led to increased consumption of virgin materials and energy (with attendant adverse environmental effects) and an increased rate of generation of solid wastes.

- There are three technical approaches that have been identified to reduce packaging material consumption and wastes: using larger containers, eliminating overpackaging of particular products, and using reusable containers. Several regulatory and fiscal measures are being evaluated for packaging control, including a tax on packaging weight, a tax on packaging weight with a rebate for the use of recycled materials, and a unit tax on rigid containers. The environmental and economic impacts of these measures for packaging waste reduction are being evaluated through ongoing EPA studies.

Beverage Containers

- Preliminary EPA analyses indicate that the reuse of refillable bottles results in lower levels of energy consumption, atmospheric emissions, and waterborne and solid wastes as compared to other existing beverage container systems (e.g., throw-away bottles and aluminum, bimetallic, and steel cans).
- Three beverage container control mechanisms have been studied: a $0.05 mandatory deposit, a ban on nonrefillable bottles, and a $0.005 tax for generating revenues for litter control. The results indicate that the ban or deposit would probably result in a reduction in litter and a reduction in material and energy consumption. However, this would probably be accompanied by a decline in beverage and container sales, resulting in economic dislocation and unemployment. Although a tax could generate significant funds for litter cleanup, it would have little effect on waste generation or resource consumption and little effect on the beverage or container industries.

Rubber Tires

- Motor vehicle tires are relatively very difficult to dispose of by means of conventional solid waste landfill or incinerator systems; therefore, many tires are disposed of inadequately or are accumulated and piled on open ground. The existing markets for recycling and reuse of old tires are the retreading industry, the rubber reclaiming industry, and the tire splitting industry. The latter two markets are small relative to the quantity of tires discarded, and the retreading market has been declining in recent years.
- Further evaluation of the technical and economic feasibility of tire processing alternatives is necessary as well as the analysis of possible mechanisms (e.g., regulations, incentives, demonstrations, and technical assistance) to implement these options.

Chapter 1

RESOURCE CONSERVATION, ENVIRONMENTAL, AND SOLID WASTE MANAGEMENT ISSUES

Resource recovery and source reduction are approaches that are responsive to three major interrelated problems of modern society: (1) conservation of virgin natural resources, (2) management of solid waste, (3) preservation of the quality of the physical environment. It is well known that the United States consumes a disproportionate share of the world's raw material supplies and that consumption rates have grown substantially with time. If these trends continue, the residuals and waste from production processes will continue to grow as well. To maintain acceptable levels of environmental quality in the face of continued growth, more stringent emission and effluent regulations will be required and will result in increased costs of air and water pollution control. At the same time, solid waste generation rates will increase, suitable land for disposal of waste will become less readily available, additional processing of waste will become necessary prior to disposal, and the costs of solid waste management will increase. It is against this background that resource recovery and source reduction activities need to be considered.

Resource recovery is defined as the use of materials, energy, and products reclaimed from solid waste. There are numerous examples of resource recovery. The secondary material industry handles millions of tons of secondary materials each year, mostly recycled from industrial waste sources. There are thousands of neighborhood recycling centers where citizens bring bottles, cans, newspapers, and other wastes separated at home. Several firms are in the process of developing, demonstrating, and marketing equipment and systems for extracting resources from mixed municipal waste. All of these activities will be discussed in greater detail in later chapters.

Source reduction is defined as the reduction in the generation of waste through a reduction in the consumption of materials or products. Examples of source reduction include the reuse of products (i.e., the retreaded tire or refillable beverage container); the use of less material-intensive products (i.e., a smaller automobile); the improvement of product durability, or extension of product lifetime; and the reduction of the number of products consumed. Source reduction is a basic conservation approach that is similar to other measures recently discussed (such as fuel rationing and automobile weight reduction for energy conservation purposes).

The focus of the present report is on "post-consumer" solid waste, defined to include the material generated by households, commercial and government office buildings, wholesale and retail trade, and other general business and service sectors of the economy. Explicitly excluded are mining, agricultural, and industrial processing and converting wastes; sewage sludge; and wastes derived from demolition and construction activities.

Thus defined, the generation of post-consumer solid waste is currently estimated to be less than 135 million tons per year. Although this constitutes a relatively small fraction of the several billions of tons of solid, liquid, and gaseous wastes produced annually by all sectors of the economy, it has become increasingly apparent that this category is of particular significance, not only from an urban solid waste collection and disposal standpoint but also from the broader resource conservation and environmental protection point of view.

This first chapter, designed to provide quantitative background and analytical perspective on some of the general issues involved in evaluating resource recovery and source reduction, is divided into four sections. The first provides estimates of the aggregate national quantity and composition of post-consumer solid waste, together with some notes on future trends. The last three sections deal, in turn, with solid waste management costs, natural resource conservation, and environmental quality issues.

The second chapter presents an analysis of existing Federal policies and their effect on virgin and secondary material use. Specifically, tax benefits for virgin materials, virgin and secondary material freight rates, and Federal procurement of products containing recycled materials are discussed.

Chapter 3 discusses the recovery and use of resources from post-consumer waste. Topics include energy recovery and the recycling of paper, steel, nonferrous metals, glass, and plastics. The EPA resource recovery demonstration grant program is reviewed along with State and local activities related to the installation of resource recovery plants. Subsidies and other incentives for plant construction, equipment investment, and use of secondary materials are also discussed in this chapter.

The fourth chapter outlines the options for product controls for resource recovery and source reduction and discusses regulatory and fiscal measures designed for this purpose.

Finally, Chapter 5 presents the results of several studies of resource recovery and source reduction strategies for specific wastes: automobiles, packaging materials, beverage containers, and rubber tires.

The three appendixes contain data on technical systems for resource recovery and research and development activities (Appendix A), analyses of several product control options (Appendix B), and a more detailed discussion of fiscal measures for source reduction (Appendix C).

THE QUANTITY AND COMPOSITION OF POST-CONSUMER SOLID WASTE

Estimates for 1971

Many of the issues relating to resource recovery and source reduction could be brought into much sharper focus with the use of detailed and consistent base-line data on waste quantities and compositions. Although there is no entirely satisfactory data base at present, Table 1 contains EPA's most recent estimate of the total quantity and material composition of post-consumer solid waste. This table also provides a cross-classification of the waste stream by product category.

With the exception of the food, yard, and miscellaneous inorganic fractions, all the product and material figures are derived from analyses of aggregate U.S. industrial material production and product marketing data, together with estimates of average product lifetime and material recovery rates. These estimates have thus been developed entirely independently of refuse collection data and sample refuse composition measurements. The food, yard, and miscellaneous inorganics categories, on the other hand, are based on average proportions of these materials reported in published refuse collection studies.[1] The data thus represent an estimate of aggregate U.S. post-consumer waste generation, net of current material recovery.

The "as generated" waste tonnages assume typical moisture content of the material prior to discard or collection. Thus, paper, textile, and wood materials have an "air-dry" moisture of approximately 7 to 15 percent, food and yard wastes contain 50 to 70 percent moisture, and all other materials are assumed to contain zero moisture. Because most published refuse composition studies reflect the moisture content of mixed wastes delivered to incinerator or landfill sites, the "as disposed" tonnages have been adjusted to reflect moisture transfer en route to the disposal site. In making interpretations and comparisons, the "as generated" weight composition is thus more relevant from the standpoint of evaluating potential material recovery from solid waste, whereas the "as disposed" weight composition should be more comparable to other published composition studies based on measured samples.

The data presented will differ from measured municipal refuse collection samples in a number of respects. For example, most sampling has typically excluded the so-called "bulky" refuse–major home appliances, furniture, and automobile tires–which according to EPA estimates accounts for about 7 million tons. In addition, the given estimates attempt to account for most but not all container and packaging waste, including a portion of that which originates at industrial plant sites and is often disposed of privately. Furthermore, virtually all composition studies have been highly localized, and

TABLE 1

MUNICIPAL SOLID WASTE GENERATION BY MATERIAL AND SOURCE, 1971

Type of material	10⁶ tons of waste by product source category							Total			
								As generated		As disposed	
	Newspapers, books, and magazines	Containers and packaging	Major household appliances	Furniture and furnishings	Clothing and footwear	Food products	Other	10⁶ tons	Percent	10⁶ tons	Percent
Paper	10.3	20.4	–	Trace	Trace	–	8.4	39.1	31.3	47.3	37.8
Glass	–	11.1	Trace	Trace	–	–	1.0	12.1	9.7	12.5	10.0
Metal:	–	6.1	1.9	.1	Trace	–	3.8	11.9	9.5	12.6	10.1
Ferrous	–	5.4	1.7	Trace	–	–	3.5	10.6	8.5	–	–
Aluminum	–	.6	.1	Trace	–	–	.1	.8	.6	–	–
Other nonferrous	–	.1	.1	Trace	–	–	.2	.4	.3	–	–
Plastic	Trace	2.5	.1	.1	.2	–	1.3	4.2	3.4	4.7	3.8
Rubber and leather	–	Trace	.1	Trace	.5	–	2.7	3.3	2.6	3.4	2.7
Textiles	Trace	Trace	–	.6	.5	–	.7	1.8	1.4	2.0	1.6
Wood	–	1.8	–	2.3	Trace	–	.5	4.6	3.7	4.6	3.7
Food	–	–	–	–	–	22.0	–	22.0	17.6	17.7	14.2
Subtotal	10.3	41.9	2.1	3.2	1.2	22.0	18.4	99.1	79.3	104.9	83.9
Yard waste								24.1	19.3	18.2	14.6
Miscellaneous inorganics								1.8	1.4	1.9	1.5
Total								125.0	100.0	125.0	100.0
Percent product source composition	8.2	33.5	1.7	2.6	1.0	17.6	14.7	–	79.3	–	83.9

most have not covered the complete spectrum of residential, commercial, institutional, and other post-consumer waste sources.

Table 1 explicitly excludes sewage sludge, demolition, and contract-construction-type wastes, as well as obsolete automobiles. (Chapter 5 presents data on automobiles.)

The total waste generation estimate of 125 million tons per year (3.32 pounds per capita per day) for 1971 is significantly lower than the widely quoted 190 million tons per year (5.3 pounds per capita per day) result estimated from the *1968 National Survey of Community Solid Waste Practices.*[2] A portion of this difference exists because the *National Survey* results included some industrial demolition and construction wastes not included in the present estimates. An additional small part of the difference could probably also be accounted for by the fact that some net moisture is added to the solid waste stream, both in the household from kitchen activities and in the storage and collection system en route to the disposal site. Nevertheless, it appears that the *National Survey* tended to somewhat overestimate the national solid waste stream. In this regard it should be noted that the *National Survey* results were themselves principally based on collected tonnage estimates (as opposed to systematic measurements) prepared by the reporting local solid waste agencies. The present estimates for total waste are judged to be accurate to within 20 percent, given the waste categories covered.

The figures for product categories represent the first attempt to estimate physical weight quantities for the product sources of the solid waste stream. The first two categories (newspapers, books, and magazines and containers and packaging) are judged to be accurate to within 10 percent. Other categories are judged to be accurate to within 25 percent.

The estimated values in Table 1 can serve as a satisfactory working basis for general analysis and policy formulation purposes at the national level. However, these composition estimates should not be utilized for detailed engineering system design purposes at the local level. The remainder of this subsection describes salient characteristics of post-consumer solid waste by examination of the generation weight data estimates.

Material Composition. Eighty percent of the waste stream is organic (including synthetics) and 20 percent inorganic (9.7 percent glass, 9.5 percent metals, and 1.4 percent miscellaneous inorganics). Of the materials recoverable as recyclable materials, only the paper, glass, and ferrous fractions each comprise more than 8 percent of the total waste stream. Other individual recyclable materials each comprise less than 3 to 4 percent of the total. Twenty to twenty-five percent of the total material weight is contributed by moisture originating principally in the food and yard waste fractions.

Product Composition. About 80 percent of solid waste (generation weight data) is derived from market product sources (as opposed to yard and garden-type wastes). Excluding food wastes, market product sources account for about 60 percent of the waste flow. It is this 75 to 80 million ton fraction at which product source reduction and material recycling programs are principally directed. If we define and measure the waste stream in terms of dry weight, the nonfood product sources account for 78 percent. Container and packaging materials currently contribute about one-third of total post-consumer waste, 42 percent of product waste, and 54 percent of nonfood product waste. The container and packaging fraction currently accounts for about 72 percent of the total mineral (combined glass and metals) fraction. In terms of individual materials, this source category contributes well over 90 percent of the glass, 75 percent of the aluminum, and at least 45 to 55 percent each of the the ferrous metal, paper, and plastic fractions of the waste stream. Consumer durable goods, including household appliances, furniture, recreational equipment, and the like, account for about 10 to 12 percent of total wastes. Newspapers, books, and magazines account for about 8 percent.

Combustion and Heat Characteristics. Roughly 80 percent of the weight of typical raw municipal refuse is composed of combustible materials. The ash content of raw refuse, including the noncombustible metal and glass fractions, is about 20 percent by weight; excluding metal and glass, the ash content of combustibles is roughly 5 percent. Total weight reduction by burning is thus on the order of 80 percent. Volume reduction by burning under optimum conditions is close to 90 percent of gross refuse and over 95 percent of the combustible fraction. Approximate heat values are 4,600 British thermal units per pound for total raw refuse and 5,500 British thermal units per pound for refuse excluding metal and glass.

Waste Generation Projections

Very little is known regarding the factors that determine total and per capita solid waste generation rates, and there is a substantial lack of historical data in this area. Components of the municipal waste stream have certainly changed over the past several decades in response to shifts in consumer technology and expenditure patterns. For example, in the past, coal and wood ash were major components of municipal waste. Similarly, food wastes on a per capita basis have declined with increased consumption of industrially prepared foods, and the introduction of kitchen waste disposals has probably caused a reduction in food waste collected by diverting it to the sewage disposal system. On the other hand, packaging waste has increased very substantially in per capita terms, and its composition has also shifted considerably, particularly in the beverage container area.

Recognition of major historical shifts such as these, together with the general lack of detailed historical data and correlation analysis, suggests caution in the construction and interpretation of gross projections of future solid waste trends or the manner in which such projections might be modified by various public policy measures.

There is currently underway at EPA a research effort designed to project the major components of post-consumer waste over the next 15 to 20 years as a base line for policy analysis.[3] Until the results of that project are available, the following discussion of future waste trends must be regarded as very crude and tentative.

If it is assumed as a first approximation that the total real consumer expenditure for durable and nondurable goods is the major variable determining post-consumer solid waste generation, then, based on the experience of the past decade, solid waste should be expected to grow at a rate of about 4.5 percent per year. However, there are a number of reasons why this growth rate should probably be considered an upper limit. First, many of the major product source components of the waste stream (most notably foods) have been growing at a much slower rate than the average. The faster growing segments, such as containers and packaging, would probably by themselves not push the overall waste growth to a higher level. The fastest growing component of the consumer goods expenditure has been the durable goods category, but items in this category comprise only a relatively small fraction of the present waste stream (about 10 to 12 percent); and there is reason to suppose that the weight of durable goods does not necessarily increase in proportion to expenditure value. Finally, fully 20 percent of the waste stream (Table 1) is composed of yard wastes, and these are not likely to grow very rapidly. Therefore, a 3.0- to 3.5-percent annual growth rate, in the absence of major material recovery or source reduction programs, would seem a more reasonable basis for projecting growth in the total solid waste stream.

To project boundaries of future waste generation rates, Table 2 summarizes projections for total waste, assuming low, medium, and high growth rates.

TABLE 2

PROJECTED TOTAL SOLID WASTE QUANTITIES*

Assumed annual compound growth (percent)	Waste (10^6 tons)		
	1980	1985	1990
2.5 (low)	155	175	200
3.5 (medium)	170	200	230
4.5 (high)	185	230	290

*1971 base = 125 million tons.

SOLID WASTE MANAGEMENT SAVINGS FROM RESOURCE RECOVERY AND SOURCE REDUCTION

The most obvious benefits from resource recovery or source reduction are the cost savings attributable to community waste collection and disposal activities.

Basically, these costs are of two broadly different types: (1) the direct costs of operating the waste collection; transportation; and landfill, incinerator, or other disposal site operations and (2) the social costs attributable to any adverse environmental quality effects associated with collection and disposal. The latter can include noise, air pollution from transport and incineration, water pollution from landfill leachate or the quenching of incinerator residues, public health problems due to poorly controlled land disposal, and general aesthetic effects associated with any of these operations.

The present section is concerned only with the first of these two cost issues. Environmental damages are discussed in the concluding section of this chapter. It should be noted, however, that the two types of costs generally tend to be inversely related to one another. That is, as the environmental damage costs of waste disposal are reduced, the greater will be the capital, labor, and other direct costs of waste management.

The purpose of this section is to provide a very preliminary quantitative perspective on the order of magnitude of the feasible direct solid waste management cost savings from a program of source reduction and resource recovery implemented on a national basis. Estimates for current and projected waste collection and disposal costs are provided first, followed by an evaluation of possibilities for their reduction. Such estimates must be viewed as gross approximations, however, because data on present waste management costs are imperfect, and future projections are obviously subject to question. In addition, costs vary so widely across the Nation that generalization is extremely difficult.

Waste Management Costs

Unit Collection Costs. Cost estimates for residential waste collection are available from a set of municipal case studies made for EPA.[4] The data show considerable variation among cities in unit collection costs--depending on quality and frequency of service, population density, degree of mechanization, and other factors. The costs range from less than $11 per ton to as high as $43 per ton. The average residential waste collection cost for the 15 cities studied was $22 per ton.

Detailed cost data on commercial and institutional collection are not available. However, the unit cost of this collection can be expected to be somewhat lower than costs of residential collection because of larger waste volumes per source and generally higher source densities in commercial areas. A very rough estimate is that the cost of commercial collection could be roughly 50 percent lower than residential collection, and commercial waste accounts for roughly 40 percent of the total municipal post-consumer solid waste collection. Using these estimates, a national average for collection costs (combining residential and commercial costs) of $18 per ton can be derived.

It is not clear whether unit collection costs should be projected to rise or fall in the future. On the one hand, a great many municipal collection systems are presently subject to considerable inefficiencies in management and design. Cost-reducing innovations and improved management could cause unit costs to decrease. On the other hand, as close-in landfill sites become scarcer and more costly, longer haul distances might well consume both equipment and labor time, thus increasing future unit costs. Because it is not known whether these counteracting trends will be of equal magnitude, no change is assumed in future collection cost per ton of waste handled.

Unit Waste Disposal Costs. Whereas unit collection costs have been found to vary among cities by as much as a factor of four to one, disposal costs per ton are known to vary by as much as twenty to one. Principal determinants of cost are (1) mode of disposal (incineration being more costly than landfill or ocean disposal), (2) quality of disposal in terms of minimizing adverse environmental impacts, (3) scale of operation (larger systems generally show lower unit costs), (4) local geophysical conditions that may cause disposal site preparation and operating factors to be more or less costly (e.g., in terms of leachate control or availability of cover soil). Thus, even with respect to sanitary landfills operated to achieve acceptable environmental quality standards, current disposal costs might be expected to vary from less than $2 per ton to as much as $6 per ton or $8 per ton in extreme cases. The previously cited case studies indicated disposal costs for 13 cities with landfills ranging from less than $1 per ton up to $6 per ton, with an average of about $3.20 per ton. The cases covered a variety of landfill performance levels and can probably be taken as reasonably representative of current urban area land disposal costs. However, it should be realized that prices actually paid for land disposal in areas where land is scarce and private landfill owners have a virtual monopoly could be higher than these figures. Charges up to $17 per ton have been reported.

The overall national average cost of solid waste disposal is probably somewhat higher than the $3.20 per ton average landfill cost, however. About 10 percent of collected waste is incinerated for volume reduction, mainly in the larger cities, and incineration-based disposal generally costs on the order of $7 to $12 per ton. In addition, it is felt that many if not most reported landfill system cost figures tend to understate the full cost, either by failing to include interest charges on capital account or (almost universally) failing to include the opportunity cost of land use (e.g., forgone tax revenues to the municipal treasury). Thus, it is estimated that current average costs of solid waste disposal operations are closer to $4 per ton on a nationwide basis.

These average costs are most likely to rise in the future, in real terms, because of environmental protection efforts (upgraded sanitary landfill and incinerator air pollution emission standards) and also because of the rising real values of alternative land use. Under these conditions, a $5 per ton average national cost of solid waste disposal is a very conservative projection for the 1980-85 period.

For areas of high population density, the waste management costs, particularly disposal costs, are likely to be significantly higher than this national average. One reason is that according to 1973 EPA estimates, incineration already accounts for roughly 30 percent of disposal in the Nation's 50 largest cities. The need to process or dispose of waste by incineration, long-haul landfill, or methods other than close-in sanitary landfill will undoubtedly increase. Landfill in these larger urban areas is usually more costly because of higher land values and the greater distances of the disposal sites from the sources of waste generation. Although accurate data are not available, it is likely that present disposal costs in larger cities, when disposal is performed in an environmentally acceptable manner and all costs are included, probably range from $5 per ton to $10 per ton and are expected to grow considerably in the future.

Total National Costs. Combining the estimated national average unit collection and disposal cost estimates with the total waste generation projections from the previous section yields total cost projections (Table 3).

Currently, with collection at $18 per ton and disposal at $4 per ton, the total national cost of handling 120 million tons of collected post-consumer solid waste would be $2.64 billion, with collection accounting for 82 percent or $2.16 billion and disposal for 18 percent or about $0.5 billion. (It should be noted that this total 1971 cost estimate of $2.64 billion is generally consistent with estimates presented in the *1968 National Survey of Community Solid Waste Practices*, from which costs of roughly

TABLE 3

U.S. POST-CONSUMER SOLID WASTE COLLECTION AND DISPOSAL COSTS

Item	1971 (estimated)	1980 (projected)			1985 (projected)		
		Low	Medium	High	Low	Medium	High
Collected waste (10^6 tons)*	120	150	160	175	165	190	220
Unit costs (dollars/ton):							
Collection	18	18	18	18	18	18	18
Disposal	4	5	5	5	5	5	5
Total	22	23	23	23	23	23	23
Total national costs [millions of dollars (1971)]:							
Collection	2,160	2,700	2,880	3,150	3,150	3,420	3,960
Disposal	480	750	800	875	875	950	1,100
Total	2,640	3,450	3,680	4,025	4,025	4,370	5,060

*It is assumed that 95 percent of the projected waste generation (Table 2) is collected.

$3.1 billion for residential and commercial waste management can be derived.[5]) Assuming no significant resource recovery or source reduction, the median projections based on a 3.5-percent annual growth in waste collections suggest a likely increase in total cost to $3.7 billion in 1980 and $4.4 billion by 1985. These represent cost increases from 1971 of 40 percent by 1980 and 66 percent by 1985.

Potential Feasible Savings

In evaluating potential savings to communities as a result of a program of source reduction or resource recovery, it is necessary to separate national average costs from those incurred in larger cities. It is also necessary to estimate the probable resource recovery system costs that will be substituted for present waste handling costs.

The savings or costs derived here apply only to the municipal waste management function; they do not include other costs or savings related to areas such as industries' utilization of secondary versus virgin materials, pollution damages, or various impacts on natural resource conservation or U.S. international trade.

Potential Savings from Resource Recovery: Collection Costs. Once solid waste has been generated at the final consumer level, collection costs must be incurred regardless of whether the material is destined for disposal or resource recovery of useful values. In particular cases, materials destined for recovery may incur greater or lesser pickup, storage, and/or transport costs than would be required under the disposal alternative. However, the most reasonable assumption is that collection costs will probably be unaffected by the introduction of widespread resource recovery programs. Thus no savings in this regard for community solid waste management activities are estimated.

Potential Savings from Resource Recovery: Disposal Costs. An active resource recovery program would involve both source separation of certain recyclable fractions of the waste stream (especially paper) as well as processing of mixed waste in large-scale centralized plants operated by the public or private sector or both. The preponderant tonnage would probably pass through processing plants.

For present purposes, it is assumed that processing plants would be used for material recovery of the noncombustible metallic and glass fractions and some portion of the paper fraction and energy recovery from the remaining combustible fractions. Furthermore, it is assumed that various grades of wastepaper (news, corrugated, and mixed) will be obtained by separate collection. A sufficient number of alternative processing plants, involving various forms of material recycling and conversion, are in a sufficiently advanced stage of design or demonstration operation to suggest technically feasible possibilities for reducing final disposal volumes more than 80 percent when implemented in combination. Indeed, some communities may find it possible to virtually eliminate "waste disposal" as conventionally defined and practiced. This could be achieved either by using the inert combustion residuals in productive landfill, as a general construction aggregate, or by conversion into structural building materials. However, total elimination of residual waste disposal may not be generally possible, and an average reduction in conventional waste disposal costs of 80 percent for participating systems is seen as a reasonable working figure for present purposes.

A discussion of the cost of resource recovery systems is presented in Chapter 3 of this report. The net cost of such systems ranges from $4 to $15 per ton and includes the total operating and capital cost plus the cost of residue disposal minus the revenue from the sale of recovered material and energy. Recovery systems will be economical in situations where the net costs are lower than the costs of waste disposal by other means. As was indicated previously, disposal costs in large cities range from $5 to $10 per ton. Therefore, in some cities with low disposal costs some resource recovery systems will not be economical, while in other cities, with disposal costs near $10 per ton, savings up to $6 per ton could be realized through resource recovery. If a saving of $3 per ton was achieved in the Nation's 50 largest cities (comprising 20 percent of the Nation's population), this would represent disposal cost savings of $100 to $130 million in 1985.

If, in addition to resource recovery through mixed waste processing, certain materials such as newspapers, corrugated boxes, and office papers are separated at the source and directly recycled (i.e., not passing through a recovery plant, and thereby not incurring processing costs), an average disposal saving of $4 per ton could be realized. Recycling 10 to 12 million tons of paper through source separation could result in disposal savings of $40 to $50 million a year. (Chapter 3 discusses the potential for recovery of source-separated paper.)

Savings from Source Reduction. By definition, source reduction involves a decrease in solid waste generation. Thus, unlike resource recovery from generated waste, source reduction implies solid waste management cost savings for both collection and disposal. In addition, source reduction programs could be effective in population areas of small density where solid waste densities might be insufficient to support an economical scale of resource recovery. Furthermore, some source reduction measures could have a positive impact on litter reduction, an aspect of the overall solid waste management problem that is not directly affected by resource recovery. Thus, for a variety of reasons, source reduction may have a unique role to play as a broadly defined tool of national solid waste management in achieving cost savings in waste handling as well as other waste management and material utilization goals.

The key questions here relate to how much and what kinds of waste reduction one can reasonably expect as the result of various types of solid waste control options. These are extremely difficult questions owing to the inherent complexities in both product design and utilization options as well as in human consumer behavior. For example, on the one hand, it is not known to what extent it would be possible to redesign consumer goods for ease of repair and increased lifetime; on the other hand, it is not known whether such goods would actually be utilized for longer periods after such design changes were instituted. EPA's studies of source reduction and product controls have not advanced sufficiently to permit confident analysis of the effect of such measures.

The effect of source reduction on waste collection costs is difficult to predict. Source reduction does not reduce the number of individual household and commercial waste sources for which service must be provided. Rather, the quantities of waste generated at each point would decrease. In theory this would permit a collection truck to make more stops and to make fewer runs to the disposal site. In practice, however, a small reduction in waste would probably not induce collection organizations to reroute trucks to take advantage of the reduction. Collection organizations are likely to react to waste reduction only if the reduction is substantial (for example, if the reduction was equal to one-third of the waste load, it would be possible to eliminate a trip to the disposal site for trucks that make three trips a day). Therefore, in the short term, waste reduction on the order of 10 to 20 percent might not result in a decrease in collection costs. However, in the long term, a reduction in the quantity or rate of growth of waste generation would forestall the need to purchase additional trucks and expand collection services and would entail a reduction in future collection costs.

Disposal savings from source reduction are a certainty almost by definition. For example, an 8-percent reduction in waste generation could result in disposal savings from source reduction of from $70 to $90 million in 1985. Such a reduction may be achievable by undertaking one or several of the waste control measures discussed in Chapters 4 and 5, such as eliminating nonrefillable beverage containers, increasing the use of bulk containers, reducing throwaway products, or eliminating excess packaging.

In conclusion, it appears on the basis of preliminary analyses that both source reduction and resource recovery have the potential of achieving reductions in the cost of solid waste management. The national savings in disposal costs resulting from a combined program of resource recovery and source reduction are in the range of over $200 million annually. This is not an insignificant amount and would represent a sizable fraction of total disposal costs in any particular year. Source reduction would also involve collection cost savings that have not been estimated.

MATERIAL CONSUMPTION AND NATURAL RESOURCE SUPPLY ISSUES

One of the principal arguments in favor of implementing resource recovery and source reduction measures lies in the potential for augmenting natural resource supplies. Two aspects of this issue are (1) resource conservation and the future adequacy of the resource base to sustain desired rates of economic growth and (2) the increasing dependency on foreign sources of crude raw materials and the consequent adverse implications for international balance of payments, strategic self-sufficiency, and international relations.

In this section historical and projected raw material consumption trends are reviewed and some of the domestic natural resource conservation and international resource dependency issues to which these trends give rise are analyzed. An attempt is also made to provide a preliminary quantitative perspective regarding the potential contribution of resource recovery and source reduction to the broad resource supply problem.

Historical Trends in U.S. Raw Material Consumption

A summary of the historical pattern of U.S. material consumption for broadly defined raw material commodity categories is shown in Table 4. Although the data are in dollars, the conversion to constant 1967 dollars provides a reasonably valid basis for assessing physical quantity growth trends within the individual commodity groupings.

The annual value of all raw materials consumed has virtually quadrupled since 1900. The greater part of this increase is accounted for by food and energy raw materials, which together tend to dominate the absolute value magnitudes. In relative growth terms, the mineral groups have exhibited the most rapid rates of increase, both for the century as a whole and for recent decades. The slowest growth has been in the forestry products and nonfood agricultural group, which is dominated by sawlogs, U.S. consumption of which has grown little over the century.

The data indicate that material consumption growth rates have increased over the past 40 years. Comparison of percent increases in consumption for the successive 20-year periods 1929-49 and 1949-69 shows that the more recent period exhibits higher growth for all categories except metallic minerals and nonfood organic materials. Similarly, the most recent 10-year period, 1959-69, shows a higher percent growth than the earlier 1949-59 decade for all raw material groups except the nonfuel, nonmetallic minerals. Thus, not only are the absolute quantities growing rapidly for most categories of crude raw materials, but there is also some evidence that even the percent growth rates have been increasing over the recent past.

A comparison of crude raw material consumption with gross national product (GNP) shows that crude and semiprocessed raw materials currently contribute a relatively small proportion to the GNP, and this contribution has been decreasing continuously since

TABLE 4

U.S. CONSUMPTION OF RAW MATERIALS, 1900-69

Year	All raw material	Food material	Nonfood agricultural and forestry products	Energy material[*]	Metallic minerals	Other nonfuel minerals
Annual value [millions of dollars (1967)]:[†]						
1900	17,358	10,448	3,347	2,447	594	499
1929	31,979	16,834	5,608	6,508	1,663	1,179
1949[‡]	44,357	22,279	7,017	10,167	2,648	1,618
1959	53,737	26,411	6,987	13,295	3,212	3,046
1969	68,590	32,275	7,431	19,170	4,046	4,338
Increase (percent):						
1909-29	43	31	27	94	71	136
1929-49	39	32	25	56	59	37
1949-59	21	19	0	31	21	88
1959-69	28	22	6	44	26	42
1949-69	55	45	6	89	53	168
1900-69	295	209	120	683	581	769

[*] Includes wood burned as fuel.

[†] Spencer, V. E. Raw materials in the United States economy: 1900-1969. Working Paper 35. Washington, U.S. Bureau of the Census, July 1972. 66 p.

[‡] 1948 and 1950 values are averaged here to minimize the effect of the 1949 recession year influence on consumption growth trends.

at least 1929–down from 13.4 percent in 1929, to 10 percent in 1959, to 8 percent in 1969. Thus, in spite of the rapid growth in raw material consumption, the GNP has expanded at an even more rapid pace. This is because the services sector of the economy (including especially government services) has grown faster than the physical goods sectors and within the goods sectors an increasing portion of the value added has come in the form of more intensive material processing, synthesizing, and fabrication of final goods in relation to material content. The only major category of raw materials that has come close to matching the aggregate GNP rate of growth is the energy materials.

General Extrapolations of Past Trends

Table 5 summarizes the results of extrapolating historical growth trends to the years 1980, 1985, 1990, and 2000. Two alternative projections are made for each year, a "high" value, based on the individual category's 1959-69 growth rate experience, and a "low" value, based on its longer term 1929-69 growth rate. The results are presented in the form of growth factors or ratios of the level projected for future years relative to corresponding 1972 values, assuming compound annual growth at the rates experienced in earlier periods. All factors are based on constant dollar value increases. Thus, on this basis, GNP is expected to reach 3.25 times its 1972 level (or an increase of 225 percent) in real terms by the year 2000 under the high growth rate assumption or 2.42 times its 1972 level (an increase of 142 percent) under the low growth rate assumption.

The projections for consumer or household sector total personal consumption closely follow those for the GNP, with durable goods growing substantially faster and nondurable goods somewhat less rapidly.

On the basis of past performance, raw material consumption should grow proportionately less rapidly than either GNP or the household final demand component of GNP. Nevertheless, annual consumption of raw materials would double by the end of the century under the high growth assumption, or increase by about 70 percent under the low growth projection. Within the mineral categories the consumption of metallic minerals would increase by about 85 to 90 percent, mineral fuels by 110 to 180 percent (most energy projections are at or above this higher figure), and other nonfuel minerals at between 150 and 170 percent. Nonfood agricultural and forestry products will probably grow by somewhat more than our higher figure of 22 percent because pulpwood and other nonsawlog components will have increasing weight within this category. Given the

TABLE 5
PROJECTED GROWTH FACTORS FOR GNP, PERSONAL CONSUMER EXPENDITURES, AND RAW MATERIAL CONSUMPTION

Item	Growth factor*							
	1980		1985		1990		2000	
	High	Low	High	Low	High	Low	High	Low
GNP	1.40	1.29	1.73	1.51	2.13	1.76	3.25	2.42
Personal consumer expenditures:								
Durable goods	1.72	1.39	2.41	1.71	3.38	2.10	6.65	3.16
Nondurable goods	1.29	1.24	1.51	1.41	1.76	1.62	2.42	2.11
Total	1.41	1.28	1.75	1.49	2.21	1.73	3.34	2.35
Material consumption:								
All raw material	1.22	1.16	1.38	1.28	1.56	1.40	2.00	1.69
Metallic minerals	1.20	1.19	1.34	1.33	1.51	1.48	1.89	1.84
Nonfuel, nonmetallic minerals	1.33	1.30	1.58	1.53	1.89	1.79	2.69	2.48
Energy material	1.34	1.24	1.60	1.41	1.92	1.62	2.77	2.11
Nonfood agricultural and forestry products	1.05	1.06	1.08	1.09	1.11	1.13	1.18	1.22
Food material	1.17	1.14	1.29	1.23	1.43	1.33	1.74	1.56
Population†	1.07		1.13		1.18		1.27	

*The projected ratio of the future year value to the 1972 (base year) value.

†Based on the most recent U.S. Department of Commerce Bureau of the Census' Series E population projections.

decrease in population growth presently projected by the U.S. Census Bureau, food consumption growth should probably be closer to our low 56 percent growth rate value. Furthermore, much of this value increase should be accounted for by continued trends toward higher valued components of the food category rather than an increase in per capita demand measured by weight of food consumed.

These projections are very crude and do not include consideration of the effect of price rises on future demand. However, they do provide a reasonably accurate quantitative perspective on the U.S. raw material requirements that would be necessary to sustain recent growth rates in our aggregate living standards for another three decades. In summary, this rate of economic growth implies, by the year 2000, an increase in overall U.S. demands on the so-called "renewable" agricultural and forestry resources of 50 percent or more and on mineral deposits of about 2.5 times our present consumption rate.

Future Raw Material Supplies and Natural Resource Conservation

Questions regarding the future adequacy of the natural resource supplies essentially relate to the capability of a finite natural resource base to sustain high and continuously rising levels of consumption for rising population levels. These questions relate not only to nonrenewable resources, such as mineral deposits, which are incapable of natural replenishment once exploited, but also they relate to renewable resources such as agricultural, forestry, and wild fishery products. The latter may, through wise investment and management, be capable of continually increased sustainable yields; however, they also may be subject to upper bounds. As in the case of many significant ocean fisheries and in many arid land irrigation projects, these resources are frequently subject to overexploitation and possible irreversible declines in productivity.

Two extreme viewpoints regarding the adequacy of resource supplies are often put forth. One is the neo-Malthusian specter of economic catastrophe that must inevitably overtake us at some future time as high-grade mineral deposits become successively exhausted, low-grade deposits become increasingly costly to discover and exploit, and the upper limits of sustained-yield resources are achieved. In this view, the finiteness of national and world resources is a basic assumption and the key issue is not whether they will last but only how long.

At the other extreme are those who believe that maintaining high per capita growth rates of material consumption depends primarily on human ingenuity. In this view, present knowledge of the extent of mineral deposits is infinitesimal compared with the unexplored reaches of the planet. Limits are those imposed by human knowledge, technology, and economic organization; natural resources are not believed to be in short supply in any real sense.

Although individual materials may be limited, the functional characteristics for which any given material is employed is regarded in principle as potentially available in other materials. Furthermore, the economic system is seen as capable of devising entirely different final products to serve traditional demands or uses—for example, telecommunications as a substitute for physical transportation.

Given this orientation, it is difficult to identify any specific natural resource commodity that is essential or critical in any absolute sense or to identify any nonreplenishable resources that are exhaustible. To the technologist, the limits to economic growth lie in man himself, not in the inherent characteristics or physical limitations of the resource base.

Historically, U.S. public policy has apparently not placed significant value on resource conservation. It could be argued that with few exceptions laws and institutions have been biased toward the short-run exploitation of natural resource assets. The Mining Law of 1872, depletion allowances, and Federal subsidies for resource exploration and technology are some of the principal ways in which material use has been encouraged throughout the history of the Nation's economic development.

Even with the most optimistic assumptions regarding the role of technology and market forces, there are a number of reasons for a more prudent approach toward resource conservation today. The current shortages of energy and materials should serve to illustrate that even if the resource base is adequate, acquisition of materials can be accompanied by severe short-term dislocations and social costs. In addition, there remain a number of areas of considerable uncertainty and risk regarding long-term future virgin resource supplies. Some of these areas of uncertainty relate to—

(1) The extent of future mineral discoveries and the cost of exploiting them. Continued high and growing rates of resource consumption could well force use of lower grade ores or energy materials at high extraction costs (in capital, labor, and energy) accompanied by high waste generation.

(2) Future growth rates of world market demands, especially of the presently underdeveloped nations of the world, and increasing competition for many commodities on world markets.

(3) Geopolitical events that could significantly affect the U.S. position in international markets for particular commodities or cause unusual demands on U.S. exports. Today U.S. dependence on foreign minerals is already high and translates into a large outflow of gold ($8 billion in 1970). By 1985, according to Department of the Interior estimates, the mineral deficit will have reached $32 billion, 1.8 percent of the GNP, up from 0.8 percent in 1970.

(4) Whether private industry will be as effective in the future as it has been in the past in innovating and organizing raw material acquisition, especially at the scale that will be required in the future on a worldwide basis.

In addition, it must be noted that the large-scale development of raw material supplies is not in itself costless. Exploration, research and development, and capital investment costs at unprecedented scales—both public and private—are the most obvious. Indeed, the Federal Government now seems prepared to invest some $10 billion in energy research and development alone over the next few years. Less obvious, but no less real, are the community and regional disruption costs associated with industry relocation due to dynamic change in raw material types and sources. These are seldom if ever factored into the private market pricing calculus as future social costs of natural resource supply.

Another aspect omitted is that the exploitation of low-grade resources (e.g., shale oil versus crude oil) is generally accompanied by external environmental costs (such as bulk shale oil residues, which require large land area for disposition) that tend not to be internalized by Government action until the impact is obvious and far advanced.

Given factors such as these, a good case can be made for a more conservative national posture regarding the rate at which the natural resource base is used.

Today the tools for assessing the social value of resource conservation are not well developed. It is difficult to compare the implicit tradeoffs, in market price or other terms, between enhanced future availability of virgin resources and present sacrifices in forgone consumption. Methods of evaluation are being developed. However, today the decision to conserve or not to conserve resources remains a matter of judgment based on consideration of environmental, economic, and political factors.

Resource Recovery and Source Reduction Implications for Resource Conservation

Both resource recovery and source reduction are almost by definition conservative. To the extent that raw materials recovered from waste streams compete with or substitute for virgin materials, the latter are saved for future use. In fact, as far as recycling is concerned, the same material units may be reused many times over a period of years, each time saving an equivalent amount of virgin raw material. In effect, the introduction of a recycle process closes the loop on an otherwise open system of extraction, consumption, and disposal.

Source reduction implies the absolute reduction of material consumption, either through redesign of the final product or packaging, through increased product lifetime, or through reduction in actual per capita consumption levels.

Detailed analyses of the practical quantitative potentials for resource recovery and source reduction to save natural virgin resources have not yet been developed. However, some preliminary evaluations with respect to resource recovery potentials have been made that suggest the order of magnitude of virgin material savings at issue.

Table 6 summarizes the recycling potentials for selected materials in post-consumer municipal waste in relation to certain measures of U.S. material consumption. The estimated recovery potentials for the individual materials are based on the following assumptions: (1) 95 percent of the waste generated is

TABLE 6
POST-CONSUMER WASTE AND MAXIMUM MATERIAL RECYCLE POTENTIALS RELATIVE TO U.S. CONSUMPTION AND PRODUCTION FOR SELECTED MATERIALS, 1971

Item	Iron	Aluminum	Copper	Lead	Tin	Paper and paperboard
Material quantity (10^3 tons):						
Post-consumer waste[*]	10,600	800	250	[†]75	[†]28	39,100
U.S. consumption	[‡]83,500	[‡]5,074	[‡]2,823	[‡]1,431	[‡]78	[§]58,770
U.S. primary production:						
Domestic raw material	[‡]54,500	[‡]377	[‡]1,411	[‡]585	–	[§]38,110
Total	[‡]81,400	[‡]3,925	[‡]1,592	[‡]666	–	[§]42,060
Percent ratio of post-consumer waste to–						
U.S. consumption	12.7	15.8	8.9	5.2	35.8	66.5
U.S. primary production:						
Domestic raw material	19.4	212.2	17.7	12.8	∞	102.6
Total	13.0	20.4	15.7	11.3	∞	93.0
Estimated maximum recovery potential:						
As percent of waste material	53	53	53	53	53	21
Total recovered (10^3 tons)	5,618	400	133	40	15	8,200
Percent ratio of potential recovery to–						
U.S. consumption	6.7	8.4	4.7	2.8	18.9	14.0
U.S. primary production:						
Domestic raw material	10.3	112.5	9.4	6.8	∞	21.5
Total	6.9	10.8	8.3	6.0	∞	19.5

[*] Based on EPA calculations.
[†] Tin can fraction only.
[‡] U.S. Bureau of Mines. 1971 Minerals yearbook. Washington, U.S. Government Printing Office, 1972.
[§] The statistics of paper. Washington, American Paper Institute, 1972.

collected, either through mixed-waste collection or specialized source-separated collection systems; (2) 70 percent of the collected waste is processed for recovery of specific material and energy values [roughly equivalent to the waste collected in U.S. standard metropolitan statistical areas (SMSA's) as defined by the U.S. Department of Commerce]; (3) with respect to paper, it is assumed that only 40 percent of SMSA collected weight is processed for fiber recovery; (4) with respect to the material actually processed for recycling, final material recovery efficiency is assumed to be 80 percent. Although crude, these assumptions are consistent with current knowledge of the waste stream itself and current (or soon-to-be-available) technology for material recovery.

The final national recovery ratios themselves–53 percent for minerals and 21 percent for total paper–represent practical maxima from a technical standpoint. They assume, for example, the existence of large-scale recovery plants serving the entire U.S. SMSA population, and they also assume implicitly a significant expansion in material-user-industry capacity in most instances. They are thus obviously not recovery values that could be implemented or achieved in the near future under any circumstances and should not be so interpreted. They represent what could conceivably be achieved with current or near-future technology under a very vigorous implementation program. Note that because they are based on current waste flow, they represent net additions to any recovery already being achieved.

Thus, for example, if the incremental recycle quantity had been achieved in 1971 for iron, then assuming the same total demand for the material, it would have been possible to have supplied about 7 percent of this demand from the municipal waste stream rather than from domestic or imported virgin sources. For the six materials shown, the percent of U.S. consumption that could have been supplied from post-consumer wastes is seen to range from a low of 3 percent for lead up to as much as 18.9 percent for paper and paperboard products.

The set of ratios in the next-to-last line of Table 6 is most indicative of U.S. natural resource conservation benefits because it relates to U.S. primary production based on domestic ore (or forests, in the case of paper). The potential reductions in primary production from virgin domestic resources could have amounted to 10.3 percent for iron, 9.4 percent for copper, 6.8 percent for lead, 21.5 percent for paper, and over 100 percent for aluminum and tin. In the case of aluminum, for which 90 percent of U.S. primary production is based on imported bauxite and alumina, it would have been possible in principle to have reduced the aluminum industry's demand for domestic bauxite to zero and also to have reduced imports. In the case of tin, where the U.S. produces negligible quantities of ore and refines less than 1 percent of our virgin consumption, the total substitution would necessarily have to come entirely at the expense of imports.

Two principal conclusions emerge from these figures. The first is that recycling post-consumer waste materials is not a panacea in the sense that it cannot be expected to supply the majority of the Nation's raw material demands. On the other hand, the substitution possibilities, both with regard to total consumption and domestic virgin material supply, are not insignificant.

In addition to these direct material resource savings, there will also accrue further net indirect savings in the form of reduced capital equipment and other material input requirements in the mining, ore reduction and beneficiation, and smelting sectors of the virgin mineral industries, as well as similar reductions in the tree harvesting, wood preparation, and wood pulping segments of the pulp and paper industry. No attempt has yet been made to evaluate these in quantitative terms. There will be, of course, some offsetting new capital goods requirements for processing the waste material, but these generally appear to be substantially less than those for virgin material.

The preceding discussion has dealt entirely with recycling or the recovery of materials as materials and the material resource savings possible from this activity. Energy resource savings can also be derived from resource recovery. Essentially these can accrue in two ways. First, the combustible organic fraction of the solid waste stream can either be burned directly as a fossil fuel substitute or processed to produce hydrocarbon fuels. EPA estimates indicate that the potential energy retrievable from municipal waste sources could supply 1.5 to 2 percent of the Nation's gross current primary energy demand. However, locally, especially in regions where heavy industry is not predominant, energy derived from solid waste could contribute a more substantial fraction to local energy demands.

The second source of energy savings is an indirect result of material recycling. As was reported in EPA's *First Annual Report to Congress on Resource Recovery*, recycling is typically less energy intensive than virgin material production, when all the stages of material acquisition, transportation, and processing are considered. One study, for example, estimates that for five metals evaluated (comprising 80 to 90 percent of energy consumption in all primary metals industries), secondary metal recovery required only 1.5 to 31 percent of the energy per ton of product required by the virgin counterpart material.[6] Other work also suggests substantial energy savings from paper and glass recycling.[7,8] Contract research projects in progress will provide a considerably firmer basis for developing quantitative perspective in this area.[9,10]

No attempt has been made here to review possibilities for converting solid waste into by-product forms of material recovery–for example, the production of brick or other building materials from incinerator residue or compost from the organic fraction. A wide variety of technologically feasible opportunities in this regard have been demonstrated.[11] However, it appears that these represent, for the most part, products with lower values from an economic standpoint than recycling and energy recovery. Nevertheless, to the extent that these physical conversion options prove viable, either as a substitute for or in addition to, recycling and energy conversion options, they would represent additional ways for conserving virgin raw materials.

In summary, virgin natural resource material savings including nonfuel mineral ores, fossil fuels, and forest resources occur as the result of resource recovery. EPA's studies to date have not attempted to evaluate in any detail the potential natural resource savings of broad source reduction programs, because many of these involve complex product redesign considerations and technical feasibility issues.

The national welfare benefits of these resource savings would accrue to future generations in the form of a larger available natural resource base. These benefits are difficult to evaluate but fall into the same category as those that national programs of research and development related to energy, minerals, and forestry activities are attempting to achieve.

ENVIRONMENTAL QUALITY PROTECTION IMPLICATIONS

In addition to solid waste management cost savings and natural resource conservation benefits, resource recovery and source reduction can also contribute to improvements in environmental quality.

Empirical evidence developed by the Council on Environmental Quality relating to the environmental impacts of resource recovery was outlined in EPA's *First Annual Report to Congress on Resource Recovery.* Comparisons between virgin and secondary material processing systems for paper, glass, and ferrous metals demonstrate substantially lower pollutant discharge levels on a ton-for-ton production basis from the use of secondary materials. These initial estimates were derived assuming 1968-70 levels of air and water pollution control.

Two EPA-sponsored projects currently underway are designed to improve upon this earlier knowledge by developing the technical data in more depth, extending the coverage to a larger number of important industries, and constructing effluent and emission comparisons on the basis of 1975 pollution control standards.[9,10] In addition, an effort has been made to develop a more sophisticated analytical basis for evaluating environmental implications of relevant resource recovery and source reduction potentials and to achieve a broader awareness of the complexities involved in the quantitative assessment of environmental benefits.

Enough is known about the relationships involved to indicate that the net national environmental effects will be beneficial in virtually all instances where resource recovery is concerned and beneficial almost by definition for source reduction. The environmental implications extend well beyond those that would occur at landfill and incinerator sites and include changes in material processing effluents and beneficial natural landscape effects. In fact, there is evidence to indicate that the beneficial effects on primary extractive and processing industry environmental impacts may substantially outweigh those relating to community solid waste disposal.

At the same time, many factors make it extremely difficult to assess the significance of these benefits. One of these is the sheer magnitude of the data and computations required to achieve quantitative perspective on specific industrial process and locational factors; however, this assessment process is well underway. Because of the highly interrelated pattern of industry material flows, the environmental benefits stemming from any particular waste recovery or reduction measure would be spread out over many different industry segments and geographic regions. Many of the benefits may appear to be marginal and not of obvious significance.

In a similar respect, it may be argued that various pollution control and other environmental protection programs scheduled over the next decade will (assuming success) achieve many if not most of the potential environmental quality improvements and the incremental benefits possible from source reduction or recycling will thus be only of limited significance. Although there is a certain validity to this statement, at least three points weaken this argument.

One is the question of whether environmental standards established will be set at socially optimal levels. Another is the question of the extent to which political and institutional factors will allow achievement of the environmental standards or whether short-term energy or material supply difficulties may compel relaxation of environmental goals and priorities. The future of environmental quality protection involves a number of risks and uncertainties, and risks of unfavorable outcomes could imply higher social costs. The third point is that many activities, by their nature, create important environmental disamenities that cannot be adequately internalized and controlled. Thus, for example, it is impossible to engage in large-scale surface mining, forest cutting, or solid waste landfill operations without disrupting landscapes and disturbing ecological systems. This would be true even assuming eventual site restoration and biological recovery. In this respect, as with the uncertainty of achieving satisfactory standards by other direct control measures, it would seem that solid waste source reduction and resource recovery options may be able to make important contributions to the Nation's environmental protection.

To the extent that source reduction and resource recovery decrease the demand for virgin material, some decrease in the number of virgin material extraction and processing sites can be anticipated. This would probably be among the most significant sources of environmental benefit, although the specific cause-effect sequence may not be easy to observe or monitor in practice. In other instances, the primary industry production sites would not achieve as large a scale of operation over time as they otherwise would, so that given degrees of pollution control will imply lower absolute emission quantities.

Table 6 indicates some of the primary industries that would be most significantly affected and suggests some preliminary inferences regarding quantitative implications. Consider, for example, substitution of recycled post-consumer ferrous metal waste for up to 10 percent of the virgin pig iron supplied from domestic iron ore mining. In this case, both iron ore mining and associated beneficiation operations would be reduced by roughly the same 10 percent, as would both coke oven and blast furnace pig iron production. Similar relative reductions would be implied for other raw materials, such as coking coal and limestone; and, in addition, the energy fuel requirements (including those for electricity generation) for all these stages of production would be similarly reduced. On the other hand, to the extent that the substitution went against imported iron ore, the implied reduction in U.S. iron ore mining would not be realized. In the case of both tin and bauxite ores, the impact would be almost totally on foreign mining operations.

Potential reductions of over 20 percent are possible for the domestic wood and primary pulp and paper processing segments of the paper industry. For copper, the environmental impact on mining would be larger in absolute terms than would be apparent from the modest 9 percent potential substitution, because copper ore averages only 0.5 percent copper.

There will, of course, be some offsetting effects. The waste material separation and processing plants will themselves be a source of some environmental side effects, although they are presently estimated to be quite minor. Of somewhat greater concern are the secondary metal smelters and secondary paper deinking and pulping operations. Nevertheless, every indication from the research thus far available suggests that these are both less energy intensive than their virgin material processing counterparts and generate, in most instances, fewer emission and effluent quantities per unit of product.

In many important cases, such as basic oxygen steelmaking, glass manufacture, and certain paper and paperboard mill applications, the final secondary recovery processing will occur as a blending of recycled and virgin raw material in primary processing plants. In such instances, additional specialized secondary plant sites will not be required.

To the extent that virgin material production is reduced by solid waste source reduction, there will be little if any offsetting environmental impacts to weigh against the savings in the virgin material sectors. Thus, per unit of waste disposal averted, source reduction can generally be expected to produce somewhat greater net environmental quality benefits than resource recovery options.

Current EPA research contracts dealing with aluminum, steel, plastics, paper, glass, and rubber will provide extensive technical data on comparative effluent and emission parameters as well as fuel, transportation use, and other environmental impact indicators. In combination with analysis regarding the potential extent of secondary material substitution and/or source reduction, these data will provide the basis for general quantitative assessments of many of the physical dimensions of the potential environmental benefits at the national level.

However, the problem of assessing the social impact remains. Although this may well prove an intractable problem from a scientific standpoint, future work should nevertheless provide policymakers with much greater quantitative perspective on the nature and degree of environmental impact.

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Chapter 2

EXISTING FEDERAL POLICIES AND THEIR EFFECTS ON VIRGIN AND SECONDARY MATERIAL USE

This chapter will discuss three existing Federal policies that affect material use: (1) freight rate regulations for virgin and secondary commodities, (2) Federal procurement specifications for products containing recycled materials, (3) tax benefits for various virgin material industries. The objective of this discussion will be to identify the impact of these measures on the use of virgin or secondary materials and to identify changes in these policies that might lead to increased rates of resource recovery or source reduction. It should be kept in mind, however, that these measures have been investigated primarily to determine impacts on resource recovery and source reduction. Many other consequences or impacts that may or may not be beneficial have not been thoroughly evaluated.

The first section of the chapter, dealing with freight rate regulations, reviews the evidence pertaining to discrimination against the shipment of secondary material by rail and ocean transport and makes several recommendations toward the establishment of a more equitable rate structure.

The second section investigates the potential for development of demand for recycled material through the Federal procurement mechanism, identifies barriers to increased Federal procurement of products containing recycled material, and recommends changes in Federal purchasing practices.

In the final section of the chapter the values of the tax benefits available to virgin material industries through the percentage depletion allowance, capital gains treatment, and various foreign tax provisions are estimated. The rationale for these benefits in terms of insuring adequacy of virgin material supply is reviewed, and the potential impact of these tax benefits on resource recovery and resource conservation is discussed.

FREIGHT RATES FOR VIRGIN AND SECONDARY MATERIALS

The current controversy concerning freight rates for secondary materials centers around the issue of discrimination. Although the Interstate Commerce Act does not refer to discrimination explicitly, it makes it unlawful for any carrier to give an undue or unreasonable advantage to any particular shipper or to subject any shipper to undue or unreasonable prejudice. To demonstrate discrimination against secondary material, it must be shown that the rate relationship between virgin and secondary materials is the source of actual injury to shippers of secondary material. This essentially requires demonstration that current rates for secondary material are too high relative to the rates for virgin material and that, as a result, there is a decrease in recycling.

Transportation Costs and Rates

Regulated freight rates are generally based on two considerations: cost and value of service. Factors that determine the cost of service of shipping a particular commodity include shipping weight, liability to damage, perishability, insurance costs, liability to damage other commodities, liability to combustion or explosion, susceptibility to theft, ease or difficulty in loading or unloading, stowability, excessive weight, excessive length, and frequency and regularity of shipments. A ratemaker considers each of these factors to establish the variable cost of providing a transportation service and then establishes a contribution above variable cost based on value-of-service considerations. This is accomplished by assessing the demand for the transportation service and pricing it accordingly. This is, in effect, charging "what the traffic will bear" and is similar to most pricing practices in commerce and industry. However, in a free market situation, competition drives prices down to the point where they exceed costs only by a minimum profit margin. When competition is limited, the situation for many transportation services, it is necessary to regulate this margin.

Discrimination could exist in a situation in which value of service considerations results in rates with a higher percentage contribution of revenue over cost for one commodity than for a competing commodity. Areas of potential discrimination can be identified by inspection of the ratio of revenue to cost for two competing commodities. If this ratio is higher for one commodity relative to the other, discrimination may exist. To eliminate discrimination, rates should be based on cost of service plus an equivalent percentage profit margin for the two commodities.

The existence of higher rail rates for secondary material than virgin material does not constitute discrimination in itself. Secondary and virgin materials have distinctly different transportation characteristics in terms of length of haul, density, and typical size of load; therefore, their rates should be different. Comparison of rates with costs is necessary to establish discrimination.

Rates and Costs for Rail Shipments

The Burden Study. Revenue-to-cost ratios are presented in the Burden study performed by the U.S. Department of Transportation.[1] Data for iron ore and iron and steel scrap are exhibited in Table 7. As can be seen for shipments in Official Territory (Northeast and Great Lakes region) and for shipments from Western to Official Territory, the revenue-to-cost ratio for ore is greater than for scrap. For other territories the results are just the opposite: there is a very high contribution of revenue over cost for scrap. (The ratios are as high as 2.33). When the figures for the entire United States are averaged, a higher revenue-to-cost ratio results for scrap than for iron ore. Table 8 indicates that for paper, in all instances, the ratio of revenue to cost is lower for wastepaper than for wood pulp. The cost techniques used in the Burden study were developed by the Interstate Commerce Commission but have not been adopted for rate determination purposes. In addition, the procedures for allocating costs over shipments of

TABLE 7

REVENUE-TO-COST RATIOS FOR IRON ORE AND IRON AND STEEL SCRAP*

Shipment location	Ratio of revenue to variable cost
Official Territory:	
Iron ore	1.43
Iron and steel scrap	1.37
Official to Southern Territory:	
Iron ore	1.41
Iron and steel scrap	2.33
Southern Territory:	
Iron ore	1.04
Iron and steel scrap	1.80
Western to Official Territory:	
Iron ore	1.51
Iron and steel scrap	1.48
Western Territory:	
Iron ore	1.21
Iron and steel scrap	1.36
Entire United States:	
Iron ore	1.30
Iron and steel scrap	1.42

*Source: An estimation of the distribution of the rail revenue contribution by commodity group and type of rail car, 1969. Washington, Office of the Secretary, U.S. Department of Transportation, Jan. 1973.

TABLE 8

SELECTED REVENUE-TO-COST RATIOS FOR WOOD PULP AND WASTEPAPER*

Shipment location	Ratio of revenue to variable cost
Southern to Official Territory:	
Wood pulp	1.81
Wastepaper	1.21
Southern Territory:	
Wood pulp	1.98
Wastepaper	1.33
Southern to Western Territory:	
Wood pulp	1.78
Wastepaper	1.33
Western Territory:	
Wood pulp	1.44
Wastepaper	1.23
Entire United States:	
Wood pulp	1.50
Wastepaper	1.15

*Source: An estimation of the distribution of the rail revenue contribution by commodity group and type of rail car, 1969. Washington, Office of the Secretary, U.S. Department of Transportation, Jan. 1973.

different weights and mileages have been questioned and criticized by transportation experts. However, these limitations notwithstanding, the following conclusions can be drawn: (1) for iron and steel scrap there is evidence of an unfavorable rail rate structure; however, this evidence is not consistent and varies regionally; (2) for wastepaper there is no evidence of an unfavorable rate structure.

EPA Freight Rate Study. One of the limitations of the Burden study is that it averaged data over different distances (e.g., shipments of distances greater than 2,500 miles were combined with movements of less than 100 miles). It is reasonable to expect that value of service rate practices would result in different revenue cost ratios for different haul lengths (as competition with other modes of transportation would vary with haul length). Therefore, aggregating shipments with very different mileages could obscure significant features of the results.

The EPA study attempted to compare moves of secondary and virgin material that meet the following three criteria: (1) movement over similar distances, (2) movements that originate in the same territory, (3) movements in high-density traffic corridors.[2]

Revenue-to-cost ratios were computed for the following secondary and virgin materials:

Virgin material	*Secondary material*
Iron ore	Iron and steel scrap
Wood pulp	Wastepaper
Glass sand	Glass cullet
Natural and synthetic rubber	Scrap and reclaimed rubber
Aluminum ingots	Aluminum scrap

The results for iron ore and iron and steel scrap are presented in Table 9. For all mileages the revenue-to-cost ratio is greater for scrap than for ore. This indicates that, in general, scrap shipments make a proportionately greater contribution to railroad profits than ore shipments.

Table 10 shows the results for wood pulp and wastepaper. In this case the secondary material is contributing less to railroad revenue than the virgin commodity.

TABLE 9

VARIATION OF REVENUE-TO-COST RATIO WITH MILEAGE FOR IRON ORE AND IRON AND STEEL SCRAP*

Mileage	Ratio of revenue to variable cost	
	Iron ore	Iron and steel scrap
100	1.92	2.17
200	1.72	2.10
300	1.56	2.04
400	1.45	2.02
500	1.33	1.94
600	1.25	1.88
700	1.17	1.83
800	1.09	1.80

*Source: Moshman Associates, Inc. An analysis of transportation rates and costs for selected virgin and secondary commodities. U.S. Environmental Protection Agency Contract No. 68-01-0790, Sept. 1973.

Table 11 presents the results for glass sand and cullet. For all mileages the revenue-to-cost ratio is higher for cullet.

The data in Table 12 indicate that reclaimed rubber makes a much higher revenue contribution above cost than natural and synthetic rubber. On the other hand, the revenue-to-cost ratio for scrap rubber is lower than for all other rubber products studied.

TABLE 10

VARIATION OF REVENUE-TO-COST RATIO WITH MILEAGE FOR WOOD PULP AND WASTEPAPER*

Mileage	Ratio of revenue to variable cost	
	Wood pulp	Wastepaper
250	2.59	1.75
500	2.43	1.66
750	2.29	1.59
1,000	2.17	1.53
1,250	2.04	1.46
1,500	1.94	1.41
1,750	1.85	–
2,000	1.75	–
2,250	1.68	–

*Source: Moshman Associates, Inc. An analysis of transportation rates and costs for selected virgin and secondary commodities. U.S. Environmental Protection Agency Contract No. 68-01-0790, Sept. 1973.

TABLE 11
VARIATION OF REVENUE-TO-COST RATIO WITH MILEAGE FOR GLASS SAND AND CULLET*

Mileage	Ratio of revenue to variable cost	
	Glass sand	Cullet
250	1.52	1.98
500	1.45	1.94
750	1.38	1.89
1,000	1.32	–

*Source: Moshman Associates, Inc. An analysis of transportation rates and costs for selected virgin and secondary commodities. U.S. Environmental Protection Agency Contract No. 68-01-0790, Sept. 1973.

TABLE 12
VARIATION OF REVENUE-TO-COST RATIO WITH MILEAGE FOR NATURAL, SYNTHETIC, SCRAP, AND RECLAIMED RUBBER*

Mileage	Ratio of revenue to variable cost		
	Natural and synthetic	Scrap	Reclaimed
250	1.92	1.41	3.33
500	1.96	1.60	2.89
750	2.04	1.85	2.60
1,000	2.08	–	–
1,250	2.10	–	–
1,500	2.15	–	–
1,750	2.72	–	–
2,000	2.25	–	–

*Source: Moshman Associates, Inc. An analysis of transportation rates and costs for selected virgin and secondary commodities. U.S. Environmental Protection Agency Contract No. 68-01-0790, Sept. 1973.

TABLE 13
VARIATION OF REVENUE-TO-COST RATIO WITH MILEAGE FOR ALUMINUM INGOTS AND SCRAP*

Mileage	Ratio of revenue to variable cost	
	Ingots	Scrap
250	2.44	1.82
500	2.38	1.72
750	2.33	1.67
1,000	2.22	1.60
1,250	2.17	1.53
1,500	2.13	1.47
1,750	2.08	1.43
2,000	2.04	1.39
2,250	2.00	1.33
2,500	1.92	1.29

*Source: Moshman Associates, Inc. An analysis of transportation rates and costs for selected virgin and secondary commodities. U.S. Environmental Protection Agency Contract No. 68-01-0790, Sept. 1973.

For aluminum, Table 13 shows that the virgin aluminum ingot has a higher revenue-to-cost ratio than aluminum scrap.

The results of this analysis do not indicate a consistent pattern of all freight rate discrimination against all secondary materials. Some secondary materials bear a larger portion of railroad operating costs than their virgin material counterparts, and some secondary materials bear a smaller portion of these costs. There is evidence that the rate structure potentially discriminates against scrap iron relative to iron ore, against cullet relative to glass sand, and against reclaimed rubber relative to other rubber products.

Ocean Freight Rates

Ocean carriers that serve U.S. ports may form shipping conferences and agree on rates for various commodities. These rates must always be filed with the Federal Maritime Commission.

Rates for a particular commodity may be either closed or open. When rates are closed, all carriers in a conference must charge the same rate for that commodity. When rates are open, individual conference carriers may establish their own rates. The rationale for open rates is to allow competition with nonconference carrier traffic in a particular commodity.

An inequitable rate structure could result if the rates are open for one material but closed for a second competing material. For example, in a recent order of investigation of rates for wastepaper and wood pulp, the Federal Maritime Commission observed that the rates on wood pulp were open, allowing each conference member to set rates based on its individual operating expenses.[3] This permitted wood pulp exporters to utilize the services of carriers having the lowest rates at the time of shipment. On the other hand, exporters of wastepaper were required to contract exclusively with conference carriers at fixed rates.

To eliminate discrimination, costs should be the only basis for setting rates. Handling and haul costs depend primarily upon the weight and volume of a shipment. Table 14 presents data on rates charged on containerized shipments of wood pulp and wastepaper. If ship space were the only consideration, the rates should be equal for containers of the same size. Table 14 indicates that this is not the case–the rates for containers of paper are higher than the rates for equivalent-sized containers of wood pulp. Furthermore, because pulp is a denser material than wastepaper, its containers should be charged a higher rate from a weight standpoint. However, the data indicate that the wastepaper rates are 16 to 19 percent higher per container than for wood pulp. As a result, the revenue per ton is 48 to 95 percent higher for wastepaper. The above evidence is based on weight and volume considerations only. There are other cost factors that must be considered before it can be determined whether an unfavorable rate structure exists.

TABLE 14

COMPARATIVE OCEAN RATES FOR WOOD PULP AND WASTEPAPER*

Material	Average revenue per 20-ft^3 container (dollars)	Average weight per 20-ft^3 container (short tons)	Average revenue (dollars/ton)
Wood pulp	327	18	18.16
Tab cards	378	14	27.00
Wastepaper	388	11	35.27

*Source: Order of Investigation, Pacific Westbound Conference. Investigation of rates, rules, and practices pertaining to the movement of wastepaper and wood pulp from United States West Coast ports to ports in Japan. Docket 72-35. [Washington], Federal Maritime Commission, June 20, 1972.

The Effects of Freight Rates on Recycling

Even if the rates for virgin and secondary materials were cost based and a rate increase was instituted, a reduction in recycling could result. The size of the reduction would depend on the elasticities of supply and demand for the secondary material. If the rate structure discriminated against secondary materials to start with, an across-the-board percent rate increase would further distort the situation.

To examine the effect of freight rates on recycling, two issues will be considered: the competition between secondary and virgin materials and the proportion of transportation costs to the total cost of using secondary materials. The first issue is directed at assessing the degree to which displacement of secondary materials by virgin materials can, in fact, occur; while the second issue involves an estimation of the sensitivity of secondary material consumption to freight costs.

Competition between Secondary and Virgin Materials. It is very difficult to generalize about the degree to which competition between secondary and virgin materials exists, and the competition issue has resulted in a major controversy in freight rate hearings. For example, it can be argued that a steel product made from scrap is technically and metallurgically equivalent to a product made from iron ore, hence these two raw materials are functional substitutes. On the other hand, it can be argued that raw material purchase decisions are affected more by sunk cost factors such as blast furnace and mine ownerships than by current material price and the use of scrap in steelmaking has remained constant regardless of the fluctuation in price.

EPA studies of the markets for secondary materials have discovered that two types of competition may exist.[4-6] First, there are certain situations in which secondary and virgin materials openly compete at the process level or in the final product marketplace. In these instances, a change in price of raw material will result in a change in consumption. In other words, freight rates can effect the short-term marginal consumption of some secondary materials. Second, long-range capital investment decisions (such as to expand capacity by building basic oxygen or scrap-intensive electric furnaces) are based, among other factors, on the cost of obtaining raw materials. In this regard, secondary and virgin materials can be said to compete in the boardroom if not in the marketplace.

Decisions concerning competition are critical in the determination of discrimination, and it is the role of the transportation regulatory agencies to decide, based on the facts presented in each case, whether a true competitive relationship exists. (These considerations provide only general guidelines for the decision process.)

Freight Rates and the Total Cost of Using Secondary Materials. Data showing rail freight rates as a percent of the delivered price of various materials are presented in Table 15. These results employ the average freight rate and delivered cost data derived for each of the commodities in the EPA study. Using these figures, a rough indication of the sensitivity of secondary material use to freight charges can be obtained. For secondary materials of lower value, such as scrap iron, wastepaper, glass cullet, and scrap rubber, the freight rate is a substantial fraction of the overall delivered cost. For these materials, a significant adjustment of freight rates could cause a significant price change; and, if the demand is elastic, a corresponding change in consumption. These materials would be affected most severely by a discriminatory rate structure. For secondary materials of higher value, such as aluminum and reclaimed rubber, the freight rate is a smaller fraction of cost, and consumption would be expected to be less sensitive to freight charges.

Data showing ocean freight rates as a percent of the price of wood pulp and wastepaper are shown in Table 16. For lower grades of wastepaper (old corrugated board), the freight rate is approximately 100 percent the material price at the shipper. For higher grade tab cards, the freight rates are approximately 25 percent of this price. In these instances freight costs are a very significant fraction of the costs of using these materials. For wood pulp the freight rate is a smaller fraction of the material price.

TABLE 16

COMPARISON OF OCEAN FREIGHT RATES WITH MATERIAL PRICE FOR WOOD PULP AND WASTEPAPER

Material	Average freight rate* (dollars/ton)	Material price† (dollars/ton)	Freight rate as a percent of material price
Wood pulp	18.16	160-180	10-11
Tab cards	27.00	110	25
Wastepaper (old corrugated)	35.27	34-37	90-105

*Order of Investigation, Pacific Westbound Conference. Investigation of rates, rules, and practices pertaining to the movement of wastepaper and wood pulp from United States West Coast ports to ports in Japan. Docket 72-35. [Washington], Federal Maritime Commission, June 20, 1972.

†At the pulpmill or paper dealer; data obtained for west coast prices in mid-1973 from the staff of *Official Board Markets*, a trade publication for the paper and pulp industry.

Conclusions and Recommendations

There is evidence to indicate that the current freight rates for some secondary materials are high relative to competing virgin materials (rail rates for scrap iron, glass cullet, and reclaimed rubber and

TABLE 15

RAIL FREIGHT RATES AS A PERCENT OF DELIVERED PRICE FOR VARIOUS MATERIALS, 1969*

Material	Average delivered price (dollars/ton)	Average freight rate (dollars/ton)	Freight rate as a percent of delivered price
Iron ore	13.94	2.39	17
Scrap iron	25.12	7.71	31
Wood pulp	128.00	8.59	7
Wastepaper	19.17	7.06	37
Glass sand	10.86	6.86	63
Glass cullet	20.00	8.83	44
Aluminum ingot	540.00	18.47	3
Aluminum scrap	285.80	16.17	6
Natural and synthetic rubber	554.83	18.83	3
Reclaimed rubber	224.00	14.90	7
Scrap rubber	14.00	11.46	78

*Source: Moshman Associates, Inc. An analysis of transportation rates and costs for selected virgin and secondary commodities. U.S. Environmental Protection Agency Contract No. 68-01-0790, Sept. 1973.

ocean rates for wastepaper). Although it is difficult to predict the degree to which a rate increase would result in lower levels of recycling, freight rates represent a substantial fraction of the cost of using many secondary materials (scrap iron, wastepaper, glass cullet, and scrap rubber). Although these findings indicate a potential for freight rate discrimination against some secondary materials, they do not prove discrimination from a legal point of view. This would require evidence of a reduction in recycling resulting from rate relationships. In addition, all secondary materials have not yet been studied. Therefore, it is recommended that the Interstate Commerce Commission and the Federal Maritime Commission, in consultation with the Environmental Protection Agency, and other appropriate agencies, conduct a thorough and complete study of rate-setting practices for all secondary materials shipped by rail and ocean carriers. The objective of this study should be to determine the extent to which discrimination against secondary materials exists. The Interstate Commerce Commission has initiated such a study.[7] Furthermore, it is recommended that future rate increases for secondary materials should only be permitted if it is determined that such increases are nondiscriminatory (i.e., that such increases are necessary to offset increased cost of shipping the specific commodities for which the increases are proposed). At any proceeding before the transportation regulatory agencies in which rates are adjusted, a specific finding should be required that such rates do not discriminate against secondary materials.

FEDERAL PROCUREMENT OF PRODUCTS CONTAINING RECYCLED MATERIALS

The Federal procurement process can play an important role in bringing about increased utilization of secondary material. In the past, Federal purchasing regulations, not unlike such practices in the private sector, have been discriminatory in requiring the use of virgin materials when technically equivalent secondary materials were available.

To evaluate the prospects for encouraging resource recovery through Government purchase of products containing recycled material, several issues will be discussed: (1) the potential for Federal procurement to develop market demand for recovered resources, (2) previous attempts to incorporate recycled materials into federally purchased products and opportunities to expand these practices, (3) the barriers to increased Federal procurement of waste-based products and the problems of administering and implementing such programs.

Federal Procurement as a Demand Creation Mechanism

Of the $66 billion in direct Federal procurement in 1970, $53.4 billion was defense and $12.6 billion was nondefense related (Table 17). These expenditures represent 3.12 and 0.74 percent of the gross domestic output, respectively.[8] Table 18 presents the procurement expenditures for various commodities as a percent of the domestic output of that commodity.

TABLE 17
DIRECT FEDERAL PROCUREMENT EXPENDITURES, 1970*

Type of expenditure	Expenditure: Billions of dollars	Expenditure: Percent of gross domestic output†
Defense	53.4	3.12
Nondefense	12.6	.74
Total	66.0	3.86

*Source: Arthur D. Little, Inc. Study of Federal purchasing to reduce solid waste. U.S. Environmental Protection Agency Contract No. 68-03-0047, [1973]. (Ongoing study.)

†$1.71 trillion in 1970.

Federal expenditures that represent a large percent of the domestic market for a commodity fall mainly in defense-related areas: ordnance, 75 percent; explosives, 48 percent; aircraft, 41 percent; communication equipment, 31 percent; ships, trains, trailers, and cycles, 19 percent; nonferrous ore mining, 19 percent; and industrial organic chemicals, 11 percent. Many of these commodities represent special-purpose equipment for which secondary material utilization would not be suitable. In addition, it would be very difficult to specify the secondary material content of a multicomponent complex product such as an airplane or motor vehicle.

TABLE 18

DIRECT FEDERAL PROCUREMENT EXPENDITURES AS A PERCENT OF DOMESTIC OUTPUT OF THAT COMMODITY, 1970*

Commodity	Defense	Nondefense†	Total
Ordnance	55.63	19.39	75.02
Explosives	45.52	2.32	47.84
Aircraft and parts	35.26	5.26	40.52
Communication equipment	27.47	3.96	31.43
Ships, trains, trailers, and cycles	14.84	4.06	18.90
Nonferrous ore mining	18.10	.51	18.61
Industrial organic chemicals	10.69	.52	11.21
Instruments and clocks	7.04	2.28	9.32
Electronic components	7.65	1.17	8.82
Office supplies	4.28	3.57	7.85
Engines and turbines	5.69	.99	6.68
Maintenance construction	3.86	2.69	6.55
Industrial gases	3.37	3.06	6.43
Batteries and X-ray and engineering electronic equipment	5.31	.82	6.13
Office computing and accounting machines	4.36	1.67	6.03
Electric apparatus and motors	4.88	.91	5.79
Optical and photographic equipment	3.43	1.96	5.39
General industrial machines and equipment	4.72	.41	5.13
Materials and handling equipment	4.54	.50	5.04
Industrial inorganic chemicals	3.76	–	3.76
Biological products	1.03	2.72	3.75
Petroleum refining	3.35	.31	3.66
Gum and wood chemicals	.03	3.58	3.61
Miscellaneous rubber products	3.35	.17	3.52
Construction and mining machinery and equipment	2.74	.18	2.92
Truck trailers	2.40	–	2.40
Household textiles and upholstery	1.96	.23	2.19
Machine shops and miscellaneous machinery	2.00	.06	2.06
Office furniture	.67	1.26	1.93
Pharmaceutical preparations	.98	.88	1.86
Commercial printing	2.69	(-.85)	1.84
Motor vehicles and parts	1.57	.16	1.73
Coal mining	1.42	.24	1.66
Metalworking machinery and equipment	1.22	.40	1.62
Chemical preparations	1.40	.10	1.50
Tire and inner tubes	1.42	.08	1.50
Cellulosic man-made fibers	1.38	–	1.38
Dairy products	.69	.67	1.36
Agricultural, forestry, and fishery products	1.31	.01	1.32
Polishes and sanitation goods	.87	.40	1.27
Service industry machines	1.08	.09	1.17
Fertilizers	.03	1.09	1.12
Fiber cans	1.12	–	1.12
Wooden containers	1.08	.01	1.09
Grain mill products	.08	.87	.95
Inorganic pigments	.92	–	.92
Iron and ferro alloy ore mining	1.70	(-.79)	.91
Sanitary paper products	.34	.56	.90
Agricultural chemicals	.34	.39	.73
Primary and secondary aluminum	.63	.03	.66
Wood preserving and miscellaneous products	.42	.23	.65
Miscellaneous plastic products	.53	.09	.62
Structural metal products	.51	.09	.60
Medicinals and botanicals	.58	–	.58
Noncellulosic organic fibers	.58	–	.58
Stampings, screws, machine products, and bolts	.44	.13	.57
Meat packing	.42	.14	.56
Hardware, plating, wire products, and valves	.38	.17	.55
Special industrial machinery	.28	.27	.55
Coated and converted paper	.32	.21	.53
Papermill products	.13	.40	.53

TABLE 18
DIRECT FEDERAL PROCUREMENT EXPENDITURES AS A PERCENT OF DOMESTIC OUTPUT OF THAT COMMODITY, 1970–*Concluded*

Commodity	Defense	Nondefense†	Total
Plastics materials and resins	.51	–	.51
Soap and other detergents	.42	.09	.51
Household furniture	.23	.27	.50
Glass and glass products	.28	.21	.49
Rubber footwear	.46	–	.46
Apparel	.26	.17	.43
Farm machinery and equipment	.36	.04	.40
Electric lighting and wiring equipment	.37	.02	.39
Primary and secondary copper	.08	.30	.38
Cyclic intermediates and crudes	.35	–	.35
Miscellaneous food products	.05	.30	.35
Cardboard boxes	.23	.09	.32
Rugs, tire cord, and miscellaneous textiles	.21	.11	.32
Book printing and publishing	1.19	(-.88)	.31
Synthetic rubber	.31	–	.31
Fabrics and yarn	.29	–	.29
Metal containers	.29	–	.29
Canned and frozen goods	.17	.10	.27
Stone and clay products	.34	(-.07)	.27
Primary and secondary iron and steel	.20	.01	.21
Bakery products	.13	.07	.20
Household appliances	.16	.04	.20
Corrugated and solid fiber boxes	.12	.05	.17
Shoes and other leather products	.11	.02	.13
Sugar	.09	.04	.13
Beverages	.09	.03	.12
Paints and allied products	.08	.04	.12
Paperboard mill products	.09	.03	.12
Stone and clay mining and quarrying	.42	(-.31)	.11
Miscellaneous manufactured products	.12	(-.02)	.10
Leather tanning	.06	.02	.08
Chemical and fertilizer mineral mining	.05	.01	.06
Confectionery and related products	.03	.02	.05
Livestock	–	.02	.02
Newspapers	.01	.01	.02
Periodicals	.01	–	.01
Sawmill and planning mill products	–	–	Negligible
Toilet preparations	–	–	–

*Source: Arthur D. Little, Inc. Study of Federal purchasing to reduce solid waste. U.S. Environmental Protection Agency Contract No. 68-03-0047, [1973]. (Ongoing study.)

†Negative numbers represent Federal subsidy.

As may be seen in Table 18, for many commodities Federal expenditures are less than 2 percent of domestic output. Included in this category are commodities that have a significant potential for secondary material content: paper and paperboard products, iron and steel, nonferrous metals, glass products, plastics, and rubber products. It is apparent that Federal purchases do not dominate the market for these commodities. Although the Federal Government is a large single consumer, Federal expenditures only represent a small fraction of combined industrial, commercial, and personal expenditures in these areas.

The direct market creation effect of Federal purchasing of waste-based products would probably be small. However, Federal procurement specifications are widely circulated and duplicated by State and local governments and some industries. If the results of Government experience with secondary material were publicized through a technical assistance and information program, more widespread utilization of secondary material in other sectors could result.

In Executive Order 11514, March 1970, the President directed Federal agencies to "initiate measures needed to direct their policies, plans, and programs so as to meet national environmental goals." This charge was reiterated by the President in the 1971 environmental message, and the General Services Administration was directed to institute a program requiring a percent of recycled fibers in purchased paper products. Other agencies have also attempted to utilize various secondary materials.

General Services Administration Recycled Paper Procurement Programs

In this program, paper procurement specifications were adjusted to require various percents of recycled fiber. The specifications are written in two parts. The first part specifies the required percent of recycled fiber from post-consumer waste sources (e.g., old corrugated boxes, newspapers, magazines, mixed wastepapers, and all fibrous materials recycled from municipal solid waste). The second part of the specification indicates the percent of secondary fiber that may be derived from converting and fabrication wastes (e.g., envelope cuttings, paper trimmings, rejected paperstock, and other papermill and textile mill wastes).

The required percents are set by taking into consideration technical performance requirements, availability of supply, and product price. No special consideration is given to suppliers who can exceed the required percents. Suppliers are required to certify that the recycled fiber content of paper items sold to the Government conform to these specifications.

The General Services Administration utilizes 144 different paper specifications. In fiscal 1972 it purchased $88 million in paper products. To date 77 specifications, representing $56.6 million in purchases, have been changed to require some percent of reclaimed fibers. Table 19 summarizes the purchases in various paper commodity areas along with the ranges of post-consumer waste and other recycled fibers.

Department of the Army Retread Tire Program

The Department of the Army has exercised a program of retreading automobile and truck tires since World War II. This program was intensified in 1970 after issuance of Executive Order 11514. In addition to reducing solid waste, retreading has substantial cost advantages. For example, a 50-percent cost saving can be achieved by retreading a tire rather than purchasing a new replacement. The Army's present goal is to retread 75 percent of the tires it replaces. Table 20 shows that progress toward the goal has been significant.

TABLE 19

SUMMARY OF RECYCLED FIBERS REQUIRED IN GENERAL SERVICES ADMINISTRATION PROCUREMENTS, FISCAL 1972*

Commodity	Purchases (millions of dollars)	Reclaimed fibers (percent)	Post-consumer waste fibers (percent)
Building materials	0.2	40	30
Office supplies	17.5	15-100	0-75
Packaging	19.5	3-100	0-90
Tissue	19.4	20-95	5-35
Total	56.6		

*Source: Data provided by the General Services Administration.

This practice could also be extended to other agencies such as the Postal Service and the General Services Administration, which also maintain motor vehicle fleets, but tire safety and performance considerations are major issues preventing this more widespread use of retreads.

TABLE 20

SUMMARY OF RETREADING PROGRAMS, DEPARTMENT OF THE ARMY*

Period	Total tires replaced	Retreaded tires	Retreads (percent)
July to December 1971	278,108	162,195	58
January to June 1972	233,798	160,248	68
July to December 1972	227,785	160,743	71

*Source: Data provided by Staff for Logistics, Maintenance Engineering Branch, Department of the Army.

Joint Committee on Printing Use of Secondary Fibers in Printing and Publishing Papers

The Joint Committee on Printing is responsible for specifications for all stationery, printing, and publishing paper used by the Federal Government. In December 1972 EPA was granted permission by the

Joint Committee on Printing to use recycled paper for internal bulletins, newsletters, and press releases on an experimental basis. No minimum percent of secondary fibers is specified, but the suppliers are required to certify recycled fiber content. EPA printing departments and the Government Printing Office are evaluating this program, which if successful may be extended to other agencies.

Barriers to Expanded Use of Recycled Materials in Federal Purchases

It is apparent that although there have been major inroads in a few areas, such as recycled paper use and tire retreading, on the whole there has not been widespread utilization of secondary materials in products purchased by the Federal Government. Uncertainty of supply, budgetary constraints, and administrative and implementation problems appear to be the major barriers to more extensive recycled material procurement.

The basic mission of the Federal supply services is to provide other Government agencies with the materials and products that they need, when they are needed, at the lowest possible cost. Use of recycled materials introduces technical and economic risk into this process. There are two aspects to the uncertainty of supply: uncertainty regarding the technical performance of products supplied and uncertainty as to the availability of secondary materials. Expanded tire retreading is inhibited by the former aspect and the General Services Administration recycled paper program was constrained by the latter (whenever a possibility of shortage occurred, the recycled fiber requirement was reduced or eliminated).

Budgetary constraints arise from the fact that for many products it is more expensive to use secondary than virgin material. This is especially true for paper. The cost difference is very significant for high-grade paper such as printing paper and stationery; for lower grade paperboards this cost constraint is not as severe. In the General Services Administration paper program, higher prices were not offered for products containing higher percents of recycled fiber. Furthermore, if the price of a recycled product was found to be unreasonably high relative to a virgin product counterpart, the recycling percents were reduced.

Administrative and implementation problems arise because of the need to revise procurement specifications and procedures and monitor and certify recycled material levels.

Conclusions and Recommendations

Federal procurement in itself will not create a significant new market demand for recycled material but can serve a valuable function in helping to establish the technical and economic factors of recycled material use. Recycling considerations introduce higher prices for purchased goods, uncertainty of supply, and an additional new administrative burden into the procurement process.

Therefore it is recommended that EPA, in conjunction with the supply agencies, develop guidelines for the inclusion of secondary material to the maximum extent practicable in products purchased by the Federal Government. These guidelines should consider level of recycled material content, costs, and monitoring procedures.

In developing these guidelines, EPA in conjunction with the procurement agencies should perform the studies necessary to establish (1) criteria for selecting materials and products to be considered in this program, (2) technical and economic limitation of recycled material use in various products, (3) present and future sources of secondary material supply.

TAX BENEFITS FOR VIRGIN MATERIALS

Various provisions of the Federal tax code result in benefits to the virgin material production sectors of the economy as opposed to the secondary material sector. In this section those tax benefits available to the virgin mineral and paper industries are identified and defined, preliminary quantitative estimates of the dollar size of the benefits are provided, and the purpose and rationale for these special tax provisions are analyzed. The objective of this discussion is to attempt to evaluate the degree to which these tax provisions influence the use of virgin rather than secondary materials.

The tax code provides a number of ways to deduct the cost of doing business from sales. All such provisions (such as accelerated depreciation, investment tax credits, and deduction of State and local taxes) that apply equally to both the virgin and secondary material industries are not considered in this report. Only those tax provisions that are available only to virgin material industries and, in effect, subsidize virgin material use, are analyzed.

Definitions of Tax Benefits for the Virgin Material Industries

Depletion Allowance. The depletion allowance is a tax deduction based on the depletion of a mineral deposit. There are two methods for calculating depletion allowance: the percentage method and the cost method. Each year the method providing the larger deduction is used. As will be explained, the tax benefit is the excess of the percentage depletion allowance above the cost depletion allowance.

Cost depletion provides for the recovery of the investment required to exploit a mineral deposit. If 10 percent of a mineral deposit is extracted in 1 year, 10 percent of the costs of acquiring that deposit can be deducted from gross income. This type of depletion is not considered to be a special benefit. It is analogous to the deduction of other costs of doing business such as the depreciation of the plant and equipment. The cost depletion allowance takes into account the exhaustion of a stock of capital, just as depreciation accounts for the predictable replacement of capital because of wear and tear and obsolescence.

Unlike cost depletion, the percentage depletion allowance bears no relationship to the cost of acquisition of a property. In fact, using the percentage depletion formula, the cumulative annual deduction from income can eventually exceed the original cost. The percentage depletion allowance is calculated by taking a fixed percentage (e.g., 22 percent for petroleum) of the gross income generated by the property. The percentage depletion allowance is limited by the fact that it cannot exceed 50 percent of the taxable income in any year. Even so, the percentage depletion allowance is in many cases much greater than the cost depletion allowance. Therefore, the percentage depletion allowance provides a tax benefit for the virgin mineral industries that has no analogous counterpart in other areas of industry or commerce. The actual benefit provided by the percentage depletion allowance is the amount of the deduction taken by the mineral industries above that allowed by the cost depletion method.

Expensing of Capital Expenditures. For most capital assets, costs required to develop, improve, or otherwise increase the value of the asset cannot be deducted from income in the year that they are incurred but must be capitalized instead (i.e., added to the cost of the asset and recovered over time through depreciation or depletion). However, the mineral industries are allowed to deduct from current income exploration and development costs that occur before a mine reaches the production stage. The timber industry is allowed to deduct from current income costs for pruning, thinning, and shaping of trees as well as disease control expenditures. The effect of this provision is to advance the timing of recovery of these costs and provide a benefit equivalent to the time value of the funds recovered.

Capital Gains Treatment. For most corporations, property held and then sold in the ordinary course of doing business is subject to ordinary income taxes at the time of sale at the maximum rate of 48 percent. But the income received from the sale of timber is subject instead to capital gains tax treatment. This special allowance for the sale of timber reduces tax payments from the ordinary 48 percent rate to the 30 percent capital gains tax rate.

In the case of coal and domestic iron ore, if after disposing of a commodity an economic interest is retained and royalties are received, such royalties are also eligible for capital gains treatment.

Foreign Tax Allowances. There are several special tax provisions available to U.S. firms with foreign-based operations. Because many U.S. firms in the virgin material business own foreign holdings, these provisions provide a benefit not available to domestic secondary material firms. Four foreign tax benefits have been identified: the foreign tax credit, the exclusion for less-developed country corporations, the exclusion for controlled foreign subsidiaries, and the Western Hemisphere trade corporation deduction.

Foreign Tax Credit. Firms operating outside the United States can deduct foreign taxes directly from their U.S. tax liability. This differs from treatment for other taxes (State and local), which are deducted from gross income. The tax credit provision results in a tax deduction twice as large as that which would occur if foreign taxes were deducted from gross income (for firms in the 48-percent tax bracket). The foreign tax credit is available to U.S. timber and mining firms operating in foreign nations.

Exclusion for Less-Developed Country Corporations. For virgin material firms operating in countries defined by the President as "less developed," there is an alternative method allowed for determining the amount of foreign tax credits available to offset U.S. taxes that increases the value of the tax credit to the U.S. firm.

Exclusion for Controlled Foreign Subsidiaries. For certain firms that do not repatriate foreign earnings, a deferral of U.S. taxes is allowed.

Western Hemisphere Trade Corporation. For firms operating within the Western Hemisphere, there is a method of calculating U.S. tax owed that reduces the taxes payable by about one-third.

Quantitative Estimates of Tax Benefits

An estimate of the magnitude of the tax payments saved by the virgin material industries because of special tax provisions was made using tax data available from various public sources. The analysis was restricted to virgin materials which compete with material that could be recycled from post-consumer solid waste. An estimate of the tax benefits was made for the following virgin materials: timber (as virgin wood pulp could be displaced by post-consumer wastepaper); oil, gas, and coal (as the use of these fuels could be displaced by energy recovery from post-consumer solid waste); iron ore (which could be displaced by steel from obsolete automobiles or metal cans); primary aluminum (which could be displaced by aluminum from discarded beverage containers and other packaging); and glass sand (which could be displaced by post-consumer cullet).

This analysis was limited by the way in which available public tax data are collected and organized. Data are normally collected by corporation and aggregated by industry. However, for purposes of this analysis it was necessary to develop estimates on a material by material basis. As an example of the problems encountered, it was found that only one-fifth of the depletion allowance statistics are reported as accruing to the mining and timber industries; the remaining four-fifths are reported as accruing to other industries in the economy. Because these tax provisions are only applicable to the mineral and timber industries, it is obvious that many firms performing mining and forestry activities are classified in the tax statistics as being predominantly involved in other production areas. Therefore, various assumptions had to be made to estimate the distribution of the aggregated tax benefits across the individual material areas.

Because of the assumptions necessary in this analysis, the following results should be viewed only as preliminary order-of-magnitude estimates. A more thorough analysis is currently underway using unpublished tax data obtained from industrial sources.[9]

The results shown in Tables 21 to 29 indicate that the capital gains treatment in the timber industry and the percentage depletion allowance in the mineral industries are the most important tax benefits.

The results for timber show an average combined benefit of $0.90 per ton of paper (Table 21). No estimate was made for the additional tax savings due to the expensing of certain capital items because data were not available.

TABLE 21
ESTIMATES OF TAX BENEFITS FOR PAPER*
PRODUCTION FROM VIRGIN MATERIALS,
1970

Type	Value for timber (millions of dollars)	Value for paper	
		Unit (dollars/ton)	Total (millions of dollars)
Capital gains treatment	[†]130.0	0.836	35.10
Foreign tax credit	[‡]9.8	0.063	2.65
Total	139.8	.899	37.75

*27 percent of all wood goes to paper production; 42 million tons of paper were produced from wood pulp in 1970.

[†] U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part 1. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.76.

[‡] EPA analysis of data from Internal Revenue Service. Statistics of income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

The combined savings for petroleum, $0.35 per barrel, and natural gas, $0.022 per 1,000 cubic feet, are shown in Table 22. In both cases the depletion allowance is of primary importance; the foreign tax credit is the next most important.

The results for iron ore, coal, bauxite, and sand are shown in Tables 23 to 26. Aluminum, mined as bauxite, receives a substantial foreign tax credit

TABLE 22
ESTIMATES OF TAX BENEFITS FOR PETROLEUM AND NATURAL GAS, 1970

Type	Value (millions of dollars)
Depletion allowance[*]	1,063
Foreign tax credit[*]	500
Intangible expenses[†]	184
Exclusion for controlled foreign subsidiaries[†]	36
Exclusion for less-developed country corporations[†]	12
Western Hemisphere trade corporation deduction[†]	5
Total	[‡]1,800

[*] EPA analysis of data from Internal Revenue Service. Statistics of Income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

[†] EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part I. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

[‡] For the petroleum industry the benefit is $0.35 per barrel, for a total of $1,350 million; and for the natural gas industry the benefit is $0.22 per 1,000 cubic feet, for a total of $450 million. The total benefit was apportioned by the quantity and value of the commodity at the wellhead: petroleum, 75 percent; natural gas, 25 percent. U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

TABLE 23
ESTIMATES OF TAX BENEFITS FOR IRON ORE, 1970

Type	Unit value[*] (dollars/ton)	Total value (millions of dollars)
Depletion allowance[†]	0.364	47.00
Foreign tax credit[†]	.229	29.60
Exploration and development expensing[‡]	.107	13.80
Exclusion for controlled foreign subsidiaries[‡]	.016	2.11
Capital gains treatment[‡]	.016	2.00
Western Hemisphere trade corporation deduction[‡]	.011	1.43
Exclusion for less-developed country corporations[‡]	.005	.70
Total	.748	96.64

[*] U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

[†] EPA analysis of data from Internal Revenue Service. Statistics of income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

[‡] EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part 1. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

TABLE 24
ESTIMATES OF TAX BENEFITS FOR COAL, 1970

Type	Unit value[*] (dollars/ton)	Total value (millions of dollars)
Depletion allowance[†]	0.072	41.00
Exploration and development expensing[‡]	.053	30.20
Foreign tax credit[†]	.011	6.00
Capital gains treatment[‡]	.005	3.00
Exclusion of controlled foreign subsidiaries[‡]	.0008	0.43
Exclusion for less-developed country corporations[‡]	.0002	0.14
Total	.142	80.77

[*] U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

[†] EPA analysis of data from Internal Revenue Service. Statistics of income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

[‡] EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part I. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

because most of the raw material is produced outside the United States. The results for all commodities are summarized in Table 27.

The maximum impact of virgin tax benefits on material prices is shown in Table 28. This price effect is shown related to virgin raw material prices and to the prices of processed materials. At the raw material stage this benefit is equivalent to between 6 and 26 percent of the selling price. At the processed material stage the maximum price effect is equivalent to between 1 and 15 percent of the price.

Table 29 shows a comparison of the tax benefits to the difference in cost of using virgin versus secondary materials. This cost differential is taken at a point in production where virgin and secondary materials are equivalent inputs to the production process. For the cases shown in Table 29, use of virgin materials always resulted in a lower cost than use of secondary materials. As the data indicate in most cases, the tax benefits for virgin materials represent a significant fraction of the cost differential.

TABLE 25
ESTIMATES OF TAX BENEFITS FOR BAUXITE (USED FOR ALUMINUM), 1970

Type	Unit value[*] (dollars/ton)	Total value (millions of dollars)
Foreign tax credit[†]	0.671	9.40
Depletion allowance[†]	.550	7.70
Exploration and development expensing[‡]	.164	2.30
Exclusion for controlled foreign subsidiaries[‡]	.049	.68
Western Hemisphere trade corporation deduction[‡]	.046	.65
Exclusion for less-developed country corporations[‡]	.016	.23
Total	1.496	20.96

[*] U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

[†] EPA analysis of data from Internal Revenue Service. Statistics of income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

[‡] EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part 1. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

TABLE 26
ESTIMATES OF TAX BENEFITS FOR SAND (USED FOR GLASS), 1970

Type	Unit value[*] (dollars/ton)	Total value (millions of dollars)
Depletion allowance[†]	0.082	0.86
Total	.082	.86

[*] U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

[†] EPA analysis based on Federal tax code regulations.

Removal of these tax provisions for virgin materials would not necessarily result in an increase in virgin material prices to the maximum extent indicated in Tables 28 and 29. In fact, it is very difficult to estimate what the actual price effect might be. Furthermore, it is even more difficult to estimate the change in virgin or secondary material consumption that would result from a price change. Several of the complications involved are as follows:

TABLE 27
SUMMARY OF ESTIMATES OF TAX BENEFITS, 1970

Product	Unit value	Total value (millions of dollars)
Paper	$0.899 per ton	37.75
Petroleum	$0.350 per barrel	1,350.00
Natural gas	$0.022 per 1,000 ft^3	450.00
Iron ore	$0.748 per ton	96.64
Coal	$0.142 per ton	80.59
Bauxite (used for aluminum)	$1.496 per ton	20.96
Sand (used for glass)	$0.082 per ton	.86

(1) The tax benefit is usually not only reflected in lower prices but could also result in higher profits to the recipient firms. Therefore, removal of the benefits would be partially translated into decreased profits rather than increased material prices. In addition, reduction or removal of the benefits may induce firms to change land holdings; modify arrangements with foreign or domestic subsidiaries; and change reserve holdings, which could reduce the impact on prices or profits.

(2) Removal or adjustment of any one tax provision could lead to increased use of other provisions, with the net impact being diminished. For example, if the percentage depletion allowance were decreased, mineral companies could shift to increased use of capital gains treatment or to cost depletion.

(3) Many firms supplying virgin materials are integrated through the basic production industries. In many cases the material value on which the percentage depletion allowance is calculated is not the value at the mine mouth but the value further along in processing. For integrated firms there is no market price to determine this value and an internal transfer price is employed instead. The questions of where in the process the value of the material is estimated and what internal transfer price is employed are of critical importance in determining the price effect of the percentage depletion allowance for any industry.

(4) Material costs in many instances are only a fraction of the price of a final product. In many cases fluctuations in material and product prices could be greater than the value of the tax benefits. These factors would tend to attenuate the price impact of subsidy removal or reduction.

(5) To calculate the change in consumption of virgin and secondary materials that would occur if the

TABLE 28

COMPARISON OF VIRGIN MATERIAL TAX BENEFITS AND PRICES

(1) Product	(2) Tax saving per unit of production	(3) Maximum material price effect of tax saving[*]	(4) Raw material price (1969-70)	(5) (3) ÷ (4)	(6) Processed material price[†] (1969-70)	(7) (3) ÷ (6)
Timber (used for paper)	$0.899 per ton	$1.80 per ton	$9.00 per ton stumpage	0.20	$130.00 per ton dry pulp[‡]	0.01
Petroleum	$0.350 per barrel	$0.70 per barrel	$3.90 per barrel crude oil at the wellhead	.23	$4.62 per barrel, No. 2 fuel oil[§]	.15
Natural gas	$0.022 per 1,000 ft^3	$0.044 per 1,000 ft^3	$0.167 per 1,000 ft^3 gas at the wellhead	.26	$0.551 per 1,000 ft^3, delivered to consumer[§]	.08
Bauxite (used for aluminum)	$1.496 per ton	$3.00 per ton	$14.00 per ton bauxite	.21	$544.00 per ton aluminum[¶]	.04
Sand (used for glass)	$0.082 per ton	$0.15 per ton	$2.38 per ton at quarry	.07	$20.00 per ton molten glass[**]	.01
Iron ore	$0.748 per ton	$1.50 per ton	$10.84 per ton at mine	.14	$41.00 per ton molten pig iron[††]	.06
Coal	$0.142 per ton	$0.28 per ton	$5.00 per ton at mine	.06		

[*] Assuming entire saving is reflected in material price and firm is in the 48-percent income tax bracket.

[†] Most probable point of competition between virgin and secondary materials.

[‡] The demand and price of timber 1971-1972. *Official Board Markets*, 1970.

[§] U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

[¶] Approximately 8 tons of bauxite are required for 1 ton of aluminum. U.S. Bureau of Mines. Mineral facts and problems. Washington, U.S. Department of the Interior, 1970.

[**] Darnay, A., and W. E. Franklin. Salvage markets for materials in solid wastes. Washington, U.S. Government Printing Office, 1972, 187 p.

[††] Approximately 1.6 tons of iron ore and 0.85 ton of coal are required for 1 ton of molten pig iron. Molten pig iron price from Midwest Research Institute. Economic studies in support of policy formation on resource recovery. Unpublished report to the Council on Environmental Quality, 1972.

tax subsidies were eliminated, it is necessary to establish the elasticities of supply and demand for all the major materials under consideration. This information currently does not exist.

While all these factors are significant and introduce considerable uncertainty into predicting what would happen if these tax provisions were eliminated, the fact remains that the virgin material production sector enjoys a significant benefit of over $2 billion annually. The value of the benefits for steel, paper, aluminum, and glass alone amount roughly to $150 million a year not counting the benefit value associated with the energy products necessary to produce these materials. No equivalent tax benefit is provided to industry to support secondary material processing.

The Rationale for Virgin Material Tax Benefits

Special tax provisions for virgin material industries result in a reallocation of resources in a manner different from that which normal market forces would allow. Such a reallocation might be desirable in situations where the free market operation would not lead to overall public benefit or economic efficiency (e.g., for national defense purposes, in instances where substantial risks skew resources away from critical areas, or where there are external costs or external benefits that are not being realized).

Minerals Industry. Tax benefits for exploration and development are aimed at reducing the risk of discovering and developing additional resources, and assuring adequate virgin material supplies. The depletion allowance enables additional investment by providing a fast return on capital. The foreign tax allowances facilitate foreign investment and enable firms to acquire resources outside the United States. However, as these measures either increase profits or reduce material prices, and result in increased produc-

TABLE 29
COMPARISON OF VIRGIN MATERIAL TAX BENEFITS WITH VIRGIN AND SECONDARY MATERIAL PRODUCT COST DIFFERENTIAL

Product	Product cost*		Cost differential in favor of virgin material	Tax benefit as a percent of virgin and secondary material cost differential
	Using virgin material (dollars/ton)	Using secondary material (dollars/ton)		
Glass	18.50	[†]16.00-20.50	-1.50-2.00	0-8
Steel (molten pig iron)[‡]	40.50	43.00	2.50	106
Paper:[§]				
Linerboard (100 percent virgin fiber compared with 25 percent secondary paper)	78.50	81.00	2.50	72
Corrugating medium [85 percent virgin (semichemical) compared with 35 percent secondary (semichemical)]	79.50	82.00	2.50	72
Combination boxboard:				
100 percent virgin (kraft) compared with 100 percent secondary (newsback)	152.50	155.50	3.00	60
100 percent virgin (kraft) compared with 100 percent secondary (whiteback)	152.50	174.50	22.00	8
Printing and writing paper (100 percent virgin compared with 100 percent secondary)	92.00	99.00	7.00	26

*Cost at the point in processing where virgin and secondary materials are equivalent inputs. Midwest Research Institute. Economic studies in support of policy formation on resource recovery. Unpublished report to the Council on Environmental Quality, 1972.

[†] Cost data modified by EPA analysis of current technology and expected transportation distances.

[‡] Iron ore and coal benefits only. (Benefits to limestone, which is also required to produce steel, are excluded.)

[§] Cost data modified from Franklin, W. E. Paper recycling; the art of the possible. Washington, American Paper Institute, 1973.

tion and consumption of materials, material reserves could tend to be depleted at a faster rate. Furthermore, by enabling virgin material prices to be maintained at an artificially low level, the development of alternative domestic sources of material and energy could be inhibited (e.g., recycling and energy recovery from post-consumer waste). Therefore, there is some question as to whether these measures lead to conservative use of resources.

There has been one major attempt to estimate the impact of the depletion allowance and exploration and development benefits on the petroleum industry.[10] This study found that elimination of the percentage depletion allowance would result in a long-run decline in oil reserves of about 3 percent, and the removal of the exploration and development expensing provision would result in an additional decline in reserves of about 4 percent. This indicates that in this industry the Federal Government is forgoing tax receipts of about $1.6 billion to maintain reserves that are valued at approximately $150 million.

Timber Industry. Before 1944, capital gains treatment was only allowed when all timber in a stand was cut and sold. Continuous production of timber sold in the ordinary course of business and timber from property held as a capital asset (e.g., a forest owned by a sawmill) was taxed at the normal rate. The rationale for making capital gains treatment available to all types of forestry was that tax pressures to liquidate timber holdings would be reduced and conservative forestry practices such as sustained yield forestry (e.g., growing trees on a particular property at the same rate as they are cut) would not be inhibited. However, a similar argument could have been made for elimination of capital gains treatment altogether. The real question is whether the timber industry would practice optimum forest development in the absence of special tax provisions. If capital gains treatment results in lower timber prices and increased wood pulp consumption, a more rapid depletion of forest resources might result. In addition, development of alternative (e.g., wastepaper) supplies might be retarded.

It should also be noted that capital gains treatment is allowed for timber harvested from leased Government lands. In this instance, there is no pressure to liquidate holdings as a capital investment by the industries not involved.

In addition to the question of whether virgin material tax benefits lead to a conservative use of resources, there is the question of whether the tax code is the most cost-efficient mechanism for providing benefits. The U.S. Department of Treasury has expressed concern over the use of the tax system for subsidy purposes.

> The main objective of the tax system is to raise revenue for governmental expenditures. Any additional uses should be few in number and should be selected only after the most stringent evaluation. Otherwise, the tax system could become so extensive and so complex that taxpayers would be unduly burdened with complex rules and the administrative machinery would be extended to many times that at present. If we use tax credits too lavishly, we could be building a bigger and bigger tax administration to collect less and less revenue.[11]

Conclusions and Recommendations

Special tax provisions that are available to the virgin material industry provide substantial benefits to this industry. When expressed on a per ton basis, the benefits are equivalent to a significant fraction of the price of virgin raw materials and are an even larger fraction of the difference in cost of using virgin versus secondary materials.

Although it is difficult to estimate the quantitative impact of these measures on material use, they certainly provide opportunity for and encourage expansion and investment in the virgin material sector. To the degree that they are reflected in reduced virgin material prices, they could result in overconsumption of virgin resources and act to inhibit the utilization of materials derived from secondary sources.

A basic dilemma arises when one considers modification or removal of these special tax provisions. The long-term effect might be the conservation of natural resources by reducing virgin material consumption and encouraging the development of materials from secondary sources. However, if in the short term virgin material supply activities are curtailed, there could be serious dislocations and shortages.

Many of these tax provisions were instituted in the past (e.g., the percentage depletion allowance was enacted in 1926) when national emphasis was on industrial development through exploitation of raw material supplies. In light of the current national goals of resource conservation, it is recommended that consideration be given to reevaluation of these tax provisions.

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Chapter 3

RECOVERY OF RESOURCES FROM POST-CONSUMER SOLID WASTE

Since the time of preparation of EPA's *First Annual Report to Congress on Resource Recovery*, the Agency's analyses of various major resource recovery subjects have made considerable progress, and activities related to recovery by Government at all levels, industry, and the public have intensified.

Today the key resource recovery issues are much better understood than a year ago, and some important trends have been identified.

In this chapter an update on resource recovery is presented, including a discussion of major trends and the results of EPA analyses. The focus of the chapter is on the recovery and recycling of materials usually found in post-consumer waste.

Discussion of resource recovery requires clear definition of the recoverable components of post-consumer waste. The waste composition discussed earlier in this report is instructive in pointing out the value recovery potentials.

Food and yard wastes and other miscellaneous combustibles such as plastics, rubber, wood, and textiles comprise 41 percent of solid waste. Because of the basic nature, form, or concentration of these wastes, conversion to energy is the most practical recovery alternative. A second alternative for most of these materials is composting; but compost markets are extremely limited, whereas energy demand is rising dramatically.

Metal and glass constitute 19 percent of the waste stream. Recovery of these materials can be accomplished in any instance where mixed waste is processed, regardless of the utilization of the remaining fraction. The type of waste processing that normally precedes energy recovery (shredding and air classification) usually provides an opportunity for recovery of metal and glass.

Paper constitutes 37 percent of solid waste, and it is estimated that 30 percent of the paper in solid waste could be recovered as a fiber source through separation at the source and separate collection. Energy recovery from the remaining 70 percent of this waste is the most feasible recovery option at this time, although as much as half of this paper could technically be recovered as fiber through mechanical separation. The value of paper as a fiber is three to four times its value as an energy source. Furthermore, recycled paper can be recovered at a later time as energy. Thus its resource value is maximized when paper is recovered as a fiber.

These conditions suggest the following strategy for value recovery from post-consumer solid waste: (1) source separation of certain paper grades and separate collection for recycling as a fiber source, (2) centralized processing of the noncombustible fractions for recovery of metals and glass, (3) conversion of the remaining combustible fractions to energy or recovery of fiber through mechanical separation if economically feasible.

This recovery strategy will provide the maximum practical recovery of value from mixed waste. The following section of this chapter discusses energy recovery from post-consumer solid waste and is followed by sections that discuss the recycling of specific materials in the waste stream.

ENERGY RECOVERY

Emergence of Energy Recovery Technology

Historical Perspective. The present might well be described as a turning point for energy recovery from solid waste. Until recently, steam recovery coupled with waste incineration was the only energy recovery technology available. The characteristics of steam recovery were not particularly attractive and relatively few cities installed these systems. There are 12 such incinerators known to be in existence at present, four of which are newer systems. Three new plants are under construction or in final planning stages. The fact that steam recovery is as costly as conventional incineration and, in addition, involves finding markets for the steam has undoubtedly curtailed interest in it. Steam is a relatively difficult product to market because it requires the existence of both a distribution system (steam pipelines) and steam users in proximity to the generating facility. There are also institutional problems associated with municipalities obtaining purchase agreements with private steam users who are accustomed to dealing with established utilities. Steam generated in the existing incinerator facilities has, in fact, not been sold but has been used by the generating municipality for heating buildings or for other purposes.

New Developments. A number of new technological developments have been underway over the past few years that are now becoming available as full-scale systems and that are greatly expanding the opportunities for energy recovery from mixed municipal waste. These systems have generally been developed by firms in private industry as new business ventures. Monsanto, Union Carbide, Devco, Garrett Research and Development (a division of Occidental Petroleum), Hercules, Black-Clawson, Horner-Schiffrin, and Combustion Equipment Associates have been some of the most active firms.

The major new systems that have been developed include the following (a more detailed description of each is presented in Appendix A):

(1) Shredded waste as a fuel. In this system refuse is shredded and separated into basic light and heavy fractions. The light fraction can then be used as a fuel substitute in utility and industrial furnaces.

(2) Pulped waste as a fuel. This entails wet pulping of refuse followed by a basic separation of organic and inorganic fractions. The entire organic fraction can then be burned or a portion of it can be recovered as fiber.

(3) Pyrolysis to produce oil or gas. Pyrolysis is chemical decomposition of waste in a high temperature and low oxygen atmosphere. Proper control of the operating conditions and further processing of the products of decomposition produce either oils (roughly equivalent to No. 6 fuel oil) or gases that can be used as fuel substances. Processing of the waste to remove inorganics generally occurs prior to pyrolysis.

(4) Pyrolysis for steam generation. In this process waste is pyrolyzed, and the pyrolysis gases are burned in an afterburner and used to generate steam. Prior separation of the waste is not required. This option has the same steam marketing problems associated with heat recovering incinerators.

(5) Incineration with electricity generation. This system involves use of gases from high-pressure incineration to drive a gas turbine electric generator.

Although these systems were developed in response to perceived market demand, the Federal Government assumed much of the risk for initial full-scale operation of the most fully developed systems by providing funds for demonstration. EPA's six major resource recovery demonstration projects are summarized in Table 30.

Economics. The ultimate attractiveness of these systems to municipalities, assuming the technology proves feasible and reliable, will depend on the net cost of the systems compared with conventional disposal by landfill or incineration. Estimates of incineration costs vary widely from as low as $7 per ton to as high as $25 per ton. Landfill costs generally average $2 per ton to $4 per ton but can be $5 per ton or higher in particular locations. Landfill costs as high as $17 per ton have occurred in areas where land space is scarce.

The current indications are that energy recovery systems are more economical than incineration and in many instances are competitive with landfill.

Potential Market for Energy Recovery Systems

Maximum Potential Energy Recovery. The annual energy producing potential of post-consumer waste from all standard metropolitan statistical areas (SMSA's) in the United States (which contain about 70 percent of the total population) has been estimated to be approximately one quadrillion (1×10^{15}) British thermal units.[1] This is roughly 1.5 percent of the Nation's 1970 energy consumption and could be a very significant new source of power. For comparison, this quantity of energy is equivalent to between 400,000 and 500,000 barrels of oil per

TABLE 30
FEDERAL RESOURCE RECOVERY DEMONSTRATION PROJECTS

Location	Process type	Resources recovered	Demonstration system size (tons/day)	Projected capital cost (millions of dollars)	Projected net cost (dollars/ton)
St. Louis, Mo.	Shredded waste as a fuel	Shredded combustible waste, ferrous metals	650	*2.40	4.00
Wilmington, Del.	Shredding for fuel recovery and materials separation	Humus, humus as fuel, ferrous metals, aluminum, glass	500	11.20	15.24
Franklin, Ohio	Wet pulping for recovery	Paper fiber, ferrous metals, glass, aluminum	150	†8.30	8.60
San Diego County, Calif.	Pyrolysis to produce fuel oil	Oil, ferrous metals, glass	200	2.75	5.92
Baltimore, Md.	Pyrolysis for steam generation	Steam, ferrous metals, glassy aggregate	1,000	15.37	6.15
Lowell, Mass.	Incinerator residue separation	Ferrous metals, glass, aluminum, copper/zinc, aggregate	250	1.74	(‡)

*720-ton-per-day plant.

†500-ton-per-day plant.

‡Profit of $0.40 per ton is obtained with a system for separation of incinerator residue only. (Incinerator costs are not included.)

TABLE 31
POTENTIAL FOR RESOURCE RECOVERY PLANT INSTALLATION*

Item	1970	1975	1980	1985
Population of the United States†	‡208,212,000	216,553,000	232,966,000	251,271,000
SMSA's with sufficient population to generate 500 tons/day of refuse:§				
Number	125	148	169	192
Percent of population living in these SMSA's	62	63	64	66
Cities with sufficient population to generate 500 tons/day of refuse:¶				
Number	56	61	80	99
Percent of population living in these cities	20	21	23	24

*Source: EPA estimates based on data in U.S. Bureau of the Census. 1970 Census of Population. 2 v. Washington, U.S. Government Printing Office, 1972.

†Based on a growth rate of 1.25 percent per year.

‡U.S. Department of Commerce Bureau of the Census' Series E population projections.

§An annual increase in per capita waste generation of 3 percent per year was assumed, beginning with 4 pounds per person per day in 1970. Population increase is assumed to be 1½ percent per year.

¶An annual increase in per capita waste generation of 3 percent per year was assumed, beginning with 4 pounds per person per day in 1970. Population increase is assumed to be 1 percent per year.

day and could have supplied the entire energy needs of the Nation for residential and commercial lighting in 1970.

The potential for installation of energy recovery plants is limited by the population size required to support plants of economical scale. Although smaller plants may be feasible in some instances, a 500-ton-per-day plant is a reasonably efficient plant scale. At a waste generation rate of 4 pounds per person per day, a plant of this size would require a population center of 250,000 people. Table 31 summarizes the number of cities and SMSA's that could support a plant of this scale projected through 1985.

These data show that 125 SMSA's could have supported a 500-ton-per-day plant in 1970, and that this number will expand to more than 190 by 1985. This represents 62 and 66 percent of the total U.S. population in those years, respectively.

Practical Potential Energy Recovery. A best estimate for total plant potential by 1985 would have to take into account certain practical factors that would limit potential plant construction. For example, the large number of political jurisdictions in SMSA's would require cooperative agreements among these governing units for utilizing these plants. Such agreements have not been easily developed in the past.

A more reasonable population base, from a feasibility standpoint, would be the single jurisdiction city population, which would yield a population base one-third the size of the SMSA base (i.e., about 20 percent of the U.S. population). Logically, the most reasonable potential for plant construction lies somewhere between that represented by central cities and that represented by SMSA's.

The second practical consideration is the type of disposal presently utilized. Locations that can landfill or dump waste at the lower cost range of $1 per ton to $3 per ton are likely to continue this practice and would not find resource recovery an attractive option. Roughly 30 percent of the waste in cities is now incinerated, and this could increase to nearly 50 percent by 1985. All waste incinerated could be channeled to recovery plants.

If the plant potential due to political and jurisdictional considerations is assumed to be midway between that represented by the plant potential in SMSA's and central cities, or 40 percent of the U.S. population, and low-cost landfill is expected to be available to 50 percent of this population, then 20 percent of the U.S. population could be expected to find energy recovery an attractive solid waste management option within the next 10 to 15 years. This would require installation of capacity to recover 60 million tons of waste by 1985, the equivalent of 200 plants of 1,000-ton-per-day capacity.

Trends in Solid Waste Energy Recovery

Factors Encouraging Energy Recovery. The rising cost and decreased availability of energy from conventional sources will tend to make solid waste an attractive alternative energy source. After a relatively stable period from 1963 to 1968, the national average price paid by steam/electric power plants for fuel has increased dramatically. From 1968 to the third quarter of 1972, the price of coal increased from $0.25 to $0.37 per million British thermal units; oil increased from $0.33 to $0.58 per million British thermal units; and gas increased from $0.25 to $0.31 per million British thermal units.[2,3] In the past year additional increases have occurred, particularly in natural gas prices.

Energy cost increases are expected to continue. Some industries are concerned about being able to obtain sufficient future quantities of energy at almost any price. The impact of these energy cost increases on attractiveness of energy recovery could be significant. If it is assumed that a doubling of the price of conventional fuels will also mean a doubling of the value of waste as a fuel, the net cost per ton of pyrolysis to produce oil would be cut in half. In the case of shredded waste as a fuel, the potential fuel cost saving to utilities would double from $4.20 per ton of waste used to $8.40 per ton of waste used and would permit the utilities to double their payments for the waste fuel.

Costs for conventional waste disposal are also expected to rise and make energy recovery more attractive as a waste management option. Accurate data on trends in waste disposal costs are not available; however, decreasing land availability for close-in landfills should tend to push cities toward more costly disposal methods, such as incineration and landfill in remote distant locations. More vigorous regulations of land disposal should take place as a result of Federal and State efforts, thus raising the costs of disposal. Standards for air emissions have already increased the cost of conventional incineration.

Another force acting to enhance the viability of resource recovery is public opinion. In many urban areas, a public sensitized to the availability of this ecologically acceptable option may refuse to support new municipal solid waste ventures unless resource recovery is a major component of the proposed solution.

In summary, it appears that future market pressures in terms of increasing costs of energy and waste disposal will tend to stimulate increased interest in resource recovery alternatives. However, the rate of resource recovery system implementation will depend on the degree of success in overcoming various institutional barriers to implementation at the State and local levels.

Present Activity by Cities and States. New developments in technology combined with the emergence of the external factors just discussed have resulted in a number of initiatives at the State and local levels. EPA is aware of at least 18 cities where energy recovery systems are under consideration, with three facilities already under construction and several others in late planning stages. At least 20 additional cities are also known to be evaluating energy recovery in a preliminary manner. State activities are also playing an important role in the new activity. A summary of activities in various States and cities follows.

Connecticut. A detailed, comprehensive plan has been developed that calls for statewide processing of solid waste for use as a fuel substitute. The creation of the Connecticut Resource Recovery Authority has been approved by the State legislature. It is charged with State plan implementation and has been given $250 million bonding authority for facility construction. Ten separate facilities are to be constructed by 1985 to process 84 percent of the State's waste. The first plant is to be operational by mid-1976.

Illinois. The State Solid Waste Office is staffing up for a grant program of $2 million, part of a $175 million environmental bond issue for solid waste planning and resource recovery demonstrations.

Minnesota. The State Solid Waste Division is preparing regulations for a law effective March 1974 that levies a $0.15-per-cubic-yard tax on waste disposed. Ninety percent of the revenue from this law is to be spent on resource recovery planning and facilities. It is expected that $3.5 million will be collected annually.

New York. Grants totaling $175 million out of a $1.1 billion environmental bond issue are to be given to local communities for resource recovery facility construction. The State legislature has already appropriated $62 million for resource recovery projects in nine communities. Several other communities are currently preparing grant applications. Some systems will be operational by late 1975 or early 1976.

Vermont. The State solid waste plan calls for mandatory separation of wastes by the householder for recycling and the construction of four regional resource recovery facilities. The proposed legislation to put this plan into effect failed to pass in 1973, but it will be reintroduced this year. Chittenden County is planning a pilot implementation of the proposed plan that should be operational by 1976.

Wisconsin. The Governor's Recycling Task Force has produced a State plan calling for a Solid Waste Recycling Authority. Legislation to create such an authority has been introduced. According to the plan, regional recycling facilities will begin operation in 1976.

Bridgeport, Connecticut. This is the first community to build a resource recovery facility under the Connecticut solid waste plan. Its facility is to produce solid waste as a supplementary fuel for the Northeast Utility boiler and should be operational by 1976.

Chicago, Illinois. Commonwealth Edison and the city made a joint commitment in August 1973 to a project to use shredded solid waste as supplementary fuel in the Commonwealth Edison boiler.

Ames, Iowa. A consultants' report has recommended shredded solid waste as a supplementary fuel for the city's utility boiler. The city is preparing a bond issue for financing. A system to provide shredded solid waste as a fuel for the boiler should be operational in late 1974.

New Orleans, Louisiana. An agreement has been reached with National Center Resource Recovery, Inc., to assist in the construction and operation of a recovery system to shred wastes and extract ferrous metals, aluminum, and glass for recycling.

Boston, Massachusetts. A contract award is to be made in mid-1974 to a private contractor to finance, design, construct, and operate a 1,200-ton-per-day (or larger) waterwall incinerator to generate steam for Boston Edison's utility steam distribution system. Plans call for the facility to be operational in late 1976.

Brockton, Massachusetts. Combustion Equipment Associates is to build an Eco-fuel (shredded solid waste) production facility. Its output is to be marketed locally.

Saugus, Massachusetts. Construction has begun by RESCO, Inc., to build a 1,200-ton-per-day steam generating incinerator. Steam is to be sold to the General Electric Company plant in Lynn, Massachusetts, when operation begins in mid-1975.

Detroit, Michigan. A project has been proposed to the City Council to build a 2,000-ton-per-day plant to burn pulped solid waste to produce steam for downtown heating and cooling.

Albany, New York. A commitment has been made to develop a system to use solid waste as a fuel supplement. Market study is underway to determine potential users of the solid waste fuel supplement. Candidate markets are Niagara Mohawk, General Electric Company, and New York State government office buildings. The system is to be operational by 1977.

Hempstead, New York. Bids are being solicited on a 20-year contract to operate a facility for wet pulping of solid waste to produce supplemental fuel.

Monroe County, New York. Plans are being made for the design, construction, and operation of a facility to provide shredded solid waste as fuel for the Rochester Gas and Electric Company and to extract paper for resale. The State has appropriated $9 million for a grant as its 50 percent share in the project.

New York, New York. Engineering design is underway to retrofit the Consolidated Edison boiler to handle shredded solid waste as a fuel supplement. A study is also being made of the feasibility of designing a new boiler that will burn 50 percent solid waste. The State has appropriated $21 million for a grant as its 50 percent share in the project.

Akron, Ohio. The City Council has approved use of revenue-sharing funds to conduct a detailed engineering study for the development of a waterwall incinerator with steam production for the central business district and B. F. Goodrich. Bids for major equipment are due in June 1975.

Memphis, Tennessee. The city and the Tennessee Valley Authority are planning to develop a facility for wet pulping of solid waste to produce supplemental fuel for the Tennessee Valley Authority boiler. Financing is being sought by the city.

Nashville, Tennessee. A waterwall incinerator to produce steam for downtown building heating and air conditioning is under construction and should be operational in summer of 1974.

Cowlitz County, Washington. The county in cooperation with the Weyerhaeuser Company is planning to build and operate a plant to generate steam from refuse and wood waste.

Grays Harbour County, Washington. Design is underway to develop a facility to generate steam from refuse and wood wastes.

South Charleston, West Virginia. A 200-ton-per-day pyrolysis plant to produce fuel gas is being built by Union Carbide.

While there has been increased interest in resource recovery, the rate of projected plant installations over the next few years is expected to be only a fraction of the practical potential. Over the next 6 years, it is projected that energy recovery will be implemented in about 20 metropolitan areas. (Recovery of approximately 70 trillion British thermal units per year, or the equivalent of twenty 1000-ton-per-day capacity plants, is anticipated.)

The rate of progress is constrained by a series of economic, marketing, management, legal, and organizational barriers that inhibit implementation including–

(1) *Technical and economic uncertainty.* Many resource recovery systems have just recently been developed, and there is a lack of comprehensive economic and engineering data. System reliability is a major concern to many potential users.

(2) *Lack of management and operational expertise at the local level.* Resource recovery systems require sophisticated technological expertise and specialized business talents that are generally not available in municipal governments. Most public works operations employ simple technology and operate in a protected business environment. Resource recovery involves the marketing of products in a competitive revenue producing business and requires flexibility to respond to changing market conditions. Many municipalities cannot provide this orientation and flexibility and are further constrained by civil service personnel requirements and municipal budgeting processes.

(3) *Uncertain return on investment.* Many of the factors mentioned above could be reduced if the private sector was involved in construction and ownership of recovery plants. However, the potential return on investment to private industry must be high enough to compensate for the risks associated with these new and untried business ventures.

Federal Stimulation of Energy Recovery

Energy recovery is emerging as a low-cost method for achieving large-scale value recovery from solid waste in the next 5 to 10 years. It is thus extremely important that the energy recovery activities and initiatives that are developing be encouraged, sustained, and accelerated. The basic options for providing stimulation are technical assistance; research, development, and demonstration; and fiscal incentives.

Technical Assistance. The need for the provision of Federal technical assistance/technology transfer and aid in the resolution of marketing and institutional problems is well established. At present the Federal Government is the focal point of information on technology, economics, markets, and institutional aspects of recovery system implementation although the capabilities of States and the consulting community are rapidly growing. EPA, through its demonstration programs; its evaluations and analysis of systems and markets; and its many contacts with States, cities, and industry, is ideally suited to be a "third party" to transfer know-how and to ensure efficient and rapid implementation of recovery systems on a national basis.

Especially today, with growing interest in resource recovery and rapidly emerging technology, some information is inaccurate and misleading. Systems, economics, market situations, financing, and other aspects of implementation are in some cases represented in ways that are either too optimistic or too pessimistic. Because of the proprietary nature of a number of systems, potential buyers often have no objective third party to turn to for advice on the feasibility and desirability of specific systems.

Perhaps most important at this early stage in energy recovery is that implementation of energy recovery systems typically will require fairly complex institutional arrangements combining one or several communities (to obtain large-scale economies), State agencies, systems developers, and utilities or other fuel buyers; a public utility commission; and buyers for metals and minerals. Direct Federal involvement in the largest and most promising of such ventures can frequently help ensure that a project will move forward rather than stagnate in jurisdictional or other disputes.

EPA has an active technical assistance program in this area to spur the adoption of energy recovery systems in the near future.

Research, Development, and Demonstration. Research and development activity in resource recovery has been carried out predominately by private corporations at their own initiative and with corporate funds. EPA has also participated in research and development through the use of contracts and grants. The best-known example of Federal research and development in this area is the development of the CPU-400, a fluid bed incinerator generating high-pressure gases to be used for driving a turbine, which in turn would drive a generator to produce electricity (under contract to the Combustion Power Company).

In light of strong private sector activity in this area—exemplified by the work of Monsanto, Garrett Research, Union Carbide, and others—there does not appear to be need at this time for Federal research and development aimed at new system development, particularly in the area of pilot plant scale development efforts. On the other hand, Federal research and development aimed at product improvement, environmental testing of systems, development and evaluation of new concepts, technology assessment, and the completion of already committed development effort is needed to support the general thrust to improve today's technical tools and to enlarge the number of resource recovery options available.

The program of Federal demonstration of new technologies at full scale has already yielded promising results and should continue to provide useful results. Most of the current interest in energy recovery stems directly from EPA demonstrations, especially the dry fuel preparation system in St. Louis.

Risks are usually associated with enlarging pilot-sized systems to full scale. Whether the benefits are worth the costs to an entity partially influences whether the demonstration is undertaken and who does it. In many, but not all, cases, the benefits to one local government acting alone may not be worth the risks. States may not have much more incentive when benefits may accrue not only to their own communities but also to others in the country. Corporations are most likely to carry the risk if they can benefit from successful demonstrations by States in many parts of the Nation. The risks can be reduced for individual communities, States, and companies by Federal assumption of some of the costs.

Although at present most technical options are in demonstration stages, and a high level of additional expenditure on additional demonstrations is neither necessary nor justifiable, EPA's demonstration effort in municipal waste recovery should and is being continued on an "as-needed" basis.

Fiscal Incentives. The need for Federal fiscal stimulation of energy recovery is far less clear. One basis for fiscal stimulation would be to provide capital that would otherwise not be available. A study recently completed for EPA found that the present capital markets are capable of supplying municipal capital needs for all types of solid waste expenditures.[4] The study notes, however, that some methods of acquiring capital are not well understood by many officials. In addition to the traditional general obligation and revenue bonds, the study lists bank loans, leasing, and private financing as alternative methods. Also, special organizations can be established to raise capital, such as public authorities, public/private corporations, and multicommunity cooperatives.

Private financing may be particularly attractive to municipalities. Several companies that have developed resource recovery systems can be expected to build the plants with their own capital and then operate the facilities for a fixed fee. Such offers have already been made by some systems developers in several instances, and others are known to be studying this approach. Many cities are more willing to accept such agreements because it not only relieves them of the responsibility for raising capital but also puts them a step away from the waste disposal obligation. One impediment to this approach is the inability of many cities to draw up long-term service contracts because their contracting authority extends only to the elective term of their officers. However, as such financing is offered, statutory change is likely to remove this barrier. In New York State, where such a package is contemplated by the city of Hempstead, the State law has been changed to allow communities to enter into long-term contracts.

States will also be able to increase municipal capital availability by using a variety of methods to obtain capital, which will then be channeled to municipalities. The funding programs of New York, Connecticut, and Minnesota are examples that may be followed by other States as well.

A second justification would be to improve the economics of the systems so that they become attractive relative to conventional disposal options. However, several of the systems already offer net costs lower than those for disposal. Trends in energy and disposal costs will tend to make energy recovery systems even more attractive in the future.

A third purpose of a Federal fiscal incentive could be to focus attention on the development of energy and material recovery from solid waste. In this regard, an incentive should be viewed more as a symbol of Federal leadership and direction rather than as a subsidy of plant costs or construction. Such a measure could be used in connection with a technical assistance program aimed at overcoming institutional barriers and could be tailored to stimulate increased private sector involvement in resource recovery implementation.

Future consideration of fiscal incentives will depend on whether the projected trends toward energy recovery develop as projected and at the projected rate and whether such fiscal incentives, on the whole, are socially desirable.

The basic Federal requirement at present is to monitor the emerging trend; to use technical assistance and other efforts to actively promote acceleration of this trend; and to determine, after additional experience has been gained, whether the additional benefits to be gained by society by further acceleration of this trend through fiscal stimulus would justify the cost involved.

As part of its general analytical effort in this area, EPA has evaluated the probable cost and recycling impact of three types of incentives for fiscal stimulation. The incentives evaluated were (1) construction grants–direct payments to municipalities covering a portion of the capital cost of recovery facilities; (2) loans–direct low-interest Federal loans or loan interest payments to the public or private sector to finance recovery facilities; (3) operating subsidies–cash payments to the owner or operator of a recovery facility equal to a percent of the market value (sale price) of plant outputs or, alternatively, equal to a fixed amount per unit quantity of output.

Data relating to the costs and potential effectiveness of three measures are presented in Tables 32 and 33. The measures are a 75-percent construction grant

TABLE 32

IMPACT OF SELECTED INCENTIVES ON THE ECONOMICS OF MUNICIPALLY OWNED RESOURCE RECOVERY PLANTS*

Type of incentive	Net plant cost (dollars/ton)					
	Fuel recovery	Materials recovery	Pyrolysis	Incineration with residue recovery	Incineration with steam recovery	Incineration with electricity recovery
None	2.70	4.77	5.42	7.18	7.05	8.97
75-percent construction grant	1.46	2.86	3.40	5.33	5.15	5.95
75-percent loan interest subsidy	2.09	3.84	4.42	6.33	6.12	7.75
30-percent cash subsidy	1.78	3.45	3.76	6.64	6.05	6.99

*Source: EPA calculation based on data in Midwest Research Institute. Resource recovery; the state of technology. Washington, U.S. Government Printing Office, Feb. 1973.

program, a payment of 75 percent of the interest (at a 5-percent interest rate) on loans taken to build recovery facilities (equaling a direct loan at 1.25 percent interest), and a 30-percent cash subsidy based on the sale price of materials to be sold from resource recovery facilities. The impact of the three incentives on the net costs of operating six types of facilities is shown in Table 32. An estimate of the effectiveness and costs of the three measures is presented in Table 33.

Conclusions and Recommendations

Technology for energy recovery has emerged and appears to be a promising alternative to conventional disposal--lower in cost in many large urban areas while also providing important energy and material resources to the economy.

State and local activity has increased and includes active planning and implementation of systems with State and private capital funding support.

Solid waste material occurring in urban areas (SMSA's), and hence readily available for recovery, could satisfy roughly 1 percent of the Nation's energy requirements, a significant proportion considering that waste is a new fuel source.

The Federal role assumed in the past 3 years appears to be well suited to the implementation of resource recovery from urban wastes. A strong, active, and expanded technical assistance/technology transfer effort is seen as essential. A research and development and demonstration effort, aimed primarily at product improvement and incremental system improvements, is also needed.

PAPER RECYCLING

Sources and Uses of Recycled Paper

Paper recycling involves the collection of discarded paper and its reuse as a fiber source by the paper industry. Roughly 40 percent of the paper recycled today is referred to as "converting" waste and is generated in industrial operations where paper and paperboard are fabricated into products. The remaining 60 percent of the paper recycled comes from discarded post-consumer waste. Corrugated boxes, mixed office and high-grade papers, and newspapers account for roughly 35 percent, 35 percent, and 30 percent, respectively, of recovered post-consumer waste. A large amount of wastepaper is not recycled and contributes to the Nation's solid waste problem.

Acquisition of Wastepaper. Post-consumer wastepaper is recovered from solid waste in two ways: salvage industry collections of old corrugated boxes and office papers from industrial and commercial establishments and municipal or private collection of old newspapers from residences. Collection of this source-segregated waste provides a clean, usable material for the paper industry. Commercial and industrial establishments, which would otherwise have to pay for wastepaper removal and disposal, generally are willing to separate paper from other materials in exchange for free collection by the secondary materials industry.

Separation of newspapers by homeowners is becoming more widely accepted, and there are more than 90 cities with active programs. For newspaper collection, cooperative action by city governments,

TABLE 33

RECYCLING IMPACT OF SELECTED INCENTIVES TO MUNICIPALITIES FOR DEVELOPMENT AND OPERATION OF RESOURCE RECOVERY PLANTS*

Type of incentive	Approximate number of plants constructed, 1976-85	Total recovery from constructed plants,* 1976-85					Total recovery over the lifetime of the plants†		Total cost to the Federal Government (millions of dollars)	Windfall‡ (percent)	Federal cost of additional recycling§ (dollars/ton)
		Heat content (10^{12} Btu's)	Materials (10^6 tons)				Heat content (10^{12} Btu's)	Materials (10^6 tons)			
			Ferrous metals	Glass	Paper	Aluminum					
75-percent construction grant	80	592	6.4	4.4	3.9	0.31	1,813	46.1	600	44	2.20
75-percent loan interest subsidy	55	410	4.4	3.0	2.8	.22	1,247	31.7	320	64	2.60
30-percent cash subsidy	65	485	5.3	3.6	3.2	.26	1,453	37.4	440	54	2.40

*This assumes a mix of the following 6 plant types: shredded refuse as a fuel, pyrolysis to produce oil, incineration with steam recovery, incineration with electricity generation, incineration with residue recovery, and wet pulping for materials recovery. As presently envisioned, 4 of these plants recover energy, 4 recover ferrous metals, 3 recover glass, 3 recover aluminum, and 1 recovers paper. It is assumed that plant construction proceeds at a constant annual rate throughout the period.

†The plants are assumed to have a 20-year life.

‡This example is based on the assumption that 35 plants would be constructed with or without the subsidies.

§This is the total cost to the Federal Government divided by the waste processed at all plants except the 35 that would have been constructed without incentives.

residents, and paper dealers is required. Cities generally have been able to achieve separate collection without adding manpower or equipment to collection services by using existing men and trucks more efficiently. EPA has conducted a detailed study of separate collection costs that is near completion.[5]

Another potential method of paper recovery is by mechanical processing of mixed municipal waste in large recovery plants. Very little paper recovery presently takes place using such systems. Both wet and dry separation techniques are under development. The Hydrasposal/Fibreclaim system, a wet process designed by the Black-Clawson Company, is presently being demonstrated in Franklin, Ohio, by EPA. An experimental air separation system is undergoing testing by the Forest Products Laboratory.

Uses of Wastepaper. Recovered paper is consumed by various segments of the paper industry for use in manufacturing paper and paperboard products. Table 34 contains a breakdown of wastepaper consumption by various segments of the paper industry.

In general, wastepaper competes with virgin fiber at the final product stage–products made from wastepaper compete with similar products made from virgin fiber. Some substitution of wastepaper occurs in mills that use primarily virgin wood pulp and vice versa. In general, however, mills built to use virgin fiber consume virgin fiber for the bulk of their outputs, and secondary mills consume wastepaper.

Status and Trends of Paper Recycling

Historical data show that domestic wastepaper recycling as a percent of consumption has declined steadily for a number of years, from 27.4 percent in 1950 to 17.7 percent in 1972. (See Table 35.) A recent study conducted for the American Paper Institute predicted that in the absence of Federal policy intervention or significant changes in consumer demand for products made from wastepaper, industry fiber input from wastepaper would drop to even lower levels than that of 1972.[6] However, it now appears that because of a combination of economic factors, there may be an increase in wastepaper demand in 1973. These factors include high demand for paper products and associated full capacity production by the paper industry; weather conditions preventing normal logging operations; a rapid increase in foreign demand for wastepaper exports from the United States, related in turn to devaluation of the U.S. dollar and foreign fiber shortages; and increasing consumer pressure for recycling, reflected in part by the wastepaper purchase specifications of the General Services Administration.

A major unknown at this point is whether the current high level of demand for wastepaper will continue. If paper production, which has increased at an annual rate of about 6 percent for the past year, returns to its historical 3 to 4 percent growth, pressures for increased use of wastepaper may

TABLE 34

WASTEPAPER UTILIZATION IN PAPER AND PAPERBOARD MANUFACTURE, 1970*

Type of paper	Total U.S. paper production	Total wastepaper consumption	Type of waste consumed			
			Mixed paper	Newspaper	Corrugated paper	Pulp substitutes and high-grade deinked paper
Total for all grades and molded pulp (10^3 tons)	53,329	12,021	2,639	2,235	4,080	3,067
Total paper (10^3 tons):	23,409	2,228	33	455	108	1,632
Newsprint	3,345	371	–	371	–	–
Printing, writing, and related	11,023	736	–	–	–	736
Tissue	3,595	971	7	76	69	819
Other	5,446	150	26	8	39	77
Total paperboard (10^3 tons):	25,465	8,330	1,766	1,473	3,779	1,312
Unbleached kraft and solid bleached	15,036	285	48	8	162	67
Semichemical	3,460	754	42	28	622	62
Combination	6,969	7,291	1,676	1,437	2,995	1,183
Construction paper and board, molded pulp, and other (10^3 tons)	4,455	1,463	840	307	193	123
Distribution (percent)	–	100.0	22.0	18.6	33.9	25.5

*Source: Paper, paperboard, and woodpulp capacity, 1970-1973. Washington, American Paper Institute, 1971.

TABLE 35

DOMESTIC PAPER CONSUMPTION AND RECYCLING*

Year	Consumption (10^6 tons)	Recycling (10^6 tons)	Recycling as a percent of consumption
1950	29.0	8.0	27.4
1951	30.6	9.9	29.7
1952	29.0	7.9	27.2
1953	31.4	8.5	27.2
1954	31.4	7.9	25.0
1955	34.7	9.0	26.0
1956	36.5	8.8	24.2
1957	35.3	8.5	24.1
1958	35.1	8.7	24.7
1959	38.7	9.4	24.3
1960	39.1	9.0	23.1
1961	40.3	9.0	22.4
1962	42.2	9.1	21.5
1963	43.7	9.6	22.0
1964	46.4	9.5	20.5
1965	49.1	10.2	20.8
1966	52.7	10.6	20.0
1967	51.9	9.9	19.4
1968	55.1	10.2	18.5
1969	58.5	10.9	18.6
1970	57.8	10.6	18.3
1971	59.1	11.0	18.6
1972	63.8	11.3	17.7

*Source: U.S. Bureau of the Census.

decrease. Foreign wastepaper demand is likely to continue at relatively high levels into the future but may not grow as rapidly as in the past year. Exports account for around 6 percent of wastepaper demand, and high levels of export can have important impacts on regional wastepaper supplies, especially on the East and West Coasts. Purchase specifications such as those of the General Services Administration, which require inclusion of post-consumer wastepaper in products, could have significant long-term impacts if they are widely adopted by cities, States, and industry. General Services Administration purchases of paper products (mostly packaging) account for less than 2 percent of total U.S. paper consumption and quantitatively are not significant in themselves. However, they could have a significant indirect impact on wastepaper consumption because General Services Administration specifications are widely used by others.

In the long term, demand for wastepaper will depend to a large extent on the price and availability of virgin wood pulp. Timber growth currently exceeds removal on a national scale; in 1970, net growth was 18.6 billion cubic feet against removals of 14.0 billion cubic feet. However, softwood timber removals, preferred for most uses of timber as well as wood pulp, were only 1 billion cubic feet less than net annual growth (9.62 billion and 10.67 billion cubic feet, respectively). Estimates by the U.S. Forest Service and others indicate that in the future the gap between timber growth and removals is likely to narrow, increasing the pressure on timber supplies and price.[7,8]

New trends in utilization of timber will also influence pulpwood availability. The use of logs with smaller diameters to make saw timber for lumber and plywood production decreases the availability of wood for pulping (small diameter logs were formerly used exclusively for pulpwood). There are also indications that labor shortages and land protection regulations may increase the cost of timber harvesting and cause virgin fiber prices to rise.

Not all of these developments will translate directly into increased wastepaper demand. Utilization of residues from logging and lumber manufacturing is expected to increase. In 1970, almost one-third of the 8.9 billion cubic feet of residues generated were utilized in making pulp and related products. Residue use is expected to reach 45 percent of available tonnage by 1985.[9]

The net impact of these trends is difficult to predict. However, even if there is no shortage of pulpwood supply in the near future, the cost of pulp is likely to increase. It is likely that new trends on the whole will make wastepaper a more attractive raw material to the paper industry, and the long-term decline in recycling relative to consumption might be arrested. Some industry observers feel that a gradual increase in wastepaper recycling is possible, but none of the indications points to an increase in recycling to anywhere near the maximum potential level discussed in the following sections.

Paper Recycling Potential

In 1970, wastepaper recycling of old newspaper, corrugated paper, and office paper was 7.4 million tons. (See Table 36.) An estimated 32 million tons of these materials were discarded into the solid waste stream in that year. As indicated in Table 36, an additional 5 to 12 million tons could have been collected in SMSA's in 1970 and would have in-

TABLE 36

WASTEPAPER AVAILABILITY (RECOVERABLE GRADES), 1970*

Type of paper	Paper (10^6 tons)						
					Recoverable		
	Consumed	Discarded to waste stream	Recovered	Generated in SMSA's	Maximum (75 percent of that generated in SMSA's)	Minimum (50 percent of that generated in SMSA's)	Additional increment recoverable
Newspaper	9.8	9.7	2.2 (22.4 percent)	7.4	5.5	3.7	1.5-3.3
Corrugated	13.3	13.2	2.6 (20.0 percent)	10.0	7.5	5.0	2.4-4.9
Mixed and high grade (primary office papers)	11.1	9.1	2.6 (23.6 percent)	8.3	6.2	4.2	1.6-3.6
Total	34.2	32.0	7.4	25.7	19.2	12.9	5.5-11.8

*Source: Franklin, W. E. Paper recycling; the art of the possible. Washington, American Paper Institute, 1973.

creased the recycling of these materials by 65 to 160 percent.

An estimated additional 15 million tons of other paper, primarily packaging materials, were also discarded into the waste stream in 1970. These materials are difficult to collect for recycling into other paper products and are generally discarded in combination with other materials in the mixed municipal waste stream. As was indicated in previous sections, conversion to energy is currently the most economical way of recovering value from discarded paper that cannot be separately collected for recycling.

Barriers to Increased Paper Recycling

Increased wastepaper recycling is inhibited by a number of factors including consumer preference, paper manufacturing economics, technology, and raw material availability. Supply of wastepaper may be an important constraint in the short term, but as was indicated previously, there are sufficient quantities of wastepaper available in the waste stream to increase consumption significantly. The most important barrier in the long run is the uncertain demand for wastepaper, which is related to the economics of paper and paperboard production.

Wastepaper Demand. Some of the more important reasons why wastepaper demand has consistently fallen short of available paper in waste are as follows:

(1) Customers have shown a preference for products made from virgin fibers, usually because of differences in appearance and quality; this has resulted in loss of a market share by products made from wastepaper and has necessitated sale of these products at a discount. Today the market image of wastepaper is changing, and public preference for "ecology paper" is a factor in the current supply shortage, especially for wastepaper grades acceptable in writing and printing stocks.

(2) The paper industry is vertically integrated into timber production and owns and manages forest resources to provide long-term stability and certainty of raw material supply. In comparison, a high degree of risk is associated with wastepaper supply. A company can seldom ensure ownership of wastepaper resources as it can of forest stands.

(3) Large, concentrated sources of timber have encouraged large production complexes with economies of scale located near forests, making woodpulp-based mills favored over smaller, less economical wastepaper-based mills.

(4) Federal tax policy (in particular, the capital gains treatment of timber) has encouraged the development of long-range timber supplies and the technology to use these supplies. There is no similar policy to encourage development of wastepaper supplies.

Most of these factors add up to economics that favor use of virgin resources. Estimates have been made of the comparative economies of wood pulp and wastepaper use, based on average cost and price conditions in 1971.[10] These estimates, presented in Table 37,

TABLE 37

COST BARRIERS TO INCREASED WASTEPAPER RECYCLING[*]

Type of paper	Mill status	Wastepaper composition (percent)		Cost differential in favor of virgin material[†] (dollars/ton of product)		
		"Virgin" case	Increased recycling case	Production (approximate)	Product value[‡]	Total
Linerboard	Old	0	25	2.50-6.75	0	2.50-6.75
	New	0	25	2.50	0	2.50
Corrugating medium	Old	0	100	(2.00)-1.00	4.50	2.50-5.50
	New	15	35	(1.00)	5.50	4.50
Folding boxboard	Old	0	100	3.00-22.00	9.00	12.00-31.00
Printing and writing	Old	0	10	(8.00)-15.00	0	(8.00)-15.00
Newsprint	Old	0	10	(20.00)-(30.00)	10.00	(10.00)-(20.00)

[*] Source: Franklin, W. E. Paper recycling; the art of the possible. Washington, American Paper Institute, 1973.

[†] Parentheses indicate negative numbers.

[‡] Approximate amount by which the market value of the product of virgin material exceeds that of the product of wastepaper.

are useful as general indicators of the comparative economics when conditions exist that are similar to those assumed in the analysis. The present condition of the paper industry deviates from these estimates: a high level of demand exists for both wood pulp and wastepaper, and the high market prices for paper products alter this relationship. Although detailed cost comparisons under present market conditions are not available, it is believed that the cost penalty of using wastepaper rather than wood pulp has decreased.

Wastepaper Supply. An established supply system for wastepaper exists—the wastepaper segment of the secondary material industry, which supplies the major portion of the wastepaper now recycled. The salvage industry collects old corrugated and office papers directly from commercial establishments and buys newspapers from volunteer groups, schools, and cities that collect them. Recently, the secondary material industry has experienced difficulties in obtaining wastepaper supplies to meet increased demand, and wastepaper prices have risen rapidly. Although it is believed that this is only a short-term situation, it appears that there are significant institutional barriers that impede the rapid increase of supplies. In addition, there is a lack of experience on the part of many municipalities in designing and implementing newspaper collection systems. (This inexperience sometimes includes the function of drafting appropriate ordinances and contracts with buyers.) Many municipal officials are wary of instituting ordinances requiring residents to separate newspapers from other waste and fear that demand will dry up, leaving them with stacks of bundled newspapers and a disappointed, irate public.

Possible increases in collection costs also deter initiation of newspaper collection programs. However, several case studies conducted by EPA indicate that by increasing the efficiency of existing municipal collection systems (e.g., use of idle equipment and full employment of underutilized workmen), a city can generally collect newspaper with little or no additional expenditure. The ultimate economies depend on the type of collection system utilized, the community's disposal cost, and the price received for the wastepaper.

Fiscal Incentives for Increased Paper Recycling

Fiscal incentives for paper recycling could take the form of tax credits or subsidy payments for wastepaper recycled or payments or credits (e.g., loans, investment tax credits, or accelerated depreciation allowances) for equipment used to recycle paper.

Estimates of increased paper recycling that could result from the application of four types of incentives have been developed. The incentives studied include a cash operating subsidy to wastepaper users equal to 30 percent of the cost of acquisition of the wastepaper, payment of 75 percent of the interest on loans for construction of new secondary papermills, a 25-percent investment tax credit for new secondary mills, and a 5-year rapid amortization provision for new mills. Results of the analysis are presented in Table 38.

TABLE 38
IMPACT OF SELECTED INCENTIVES FOR PAPER RECYCLING[*]

Incentive	Additional recycling, 1976-85 (10^6 tons)	Additional recycling over life of equipment[†] (10^6 tons)	Total cost of incentives (millions of dollars)	Overall cost to Federal Government of additional recycling (dollars/ton)	Average windfall (percent)
30-percent operating subsidy	43.7	101	[‡]2,981	14.75	74
75-percent loan interest payment	29.4	68	[‡]734	5.40	68
25-percent investment tax credit	23.0	53	305	5.75	61
5-year rapid amortization	11.9	28	4	2.90	79

[*] Source: Resource Planning Associates. Study of Federal subsidies to stimulate resource recovery. U.S. Environmental Protection Agency Contract No. 68-03-0195, [1973]. (Ongoing study.)

[†] The subsidy program is assumed to last for 10 years, from 1976 to 1985; and the equipment life is assumed to be 15 years. The subsidy beyond 1985 is applied only to those obligations made during the 10-year program (i.e., it does not apply to equipment purchased after 1985).

[‡] Approximately half the cost of this subsidy would be recaptured in tax because this subsidy is treated as ordinary income.

The basis for this analysis was that all post-consumer grades of wastepaper recycled would be eligible for the incentives–ongoing recycling as well as new recycling expressly induced by the incentive. This provision gives rise to a "windfall" feature of such a program–payments are made for some recycling or investment that would take place without the incentive. A base-line was constructed by estimating for the period 1976-85 the level of recycling that would take place without the incentives, and this base-line recovery level corresponds to a recycling rate of 18 percent of total paper consumption.

Net increases in post-consumer paper recycling above the base-line range from a high of 4.4 million tons a year for the 30-percent operating incentive to 1.2 million tons a year for the 5-year amortization measure. Federal expenditures per ton of new recycling range from $14.75 to $2.90. The data indicate that fiscal incentive measures applicable to all post-consumer grades of paper are accompanied by a very high windfall–equivalent to 60 to 80 percent of program costs.

Conclusions and Recommendations

Paper recovery using separate collection techniques is economically and technically feasible. Recovery of paper by mechanical separation has been demonstrated and is economically attractive when alternative disposal costs are high.

At present, the United States is in a situation of fiber shortage; the paper industry is operating at capacity and straining; wastepaper and pulp prices are up; foreign demand is up; and industry speaks of supply shortages.

Given this situation, and the considerable uncertainties associated with its probable duration, only a limited number of conclusions can be drawn with confidence. It appears clear that for the immediate future, activities that increase the supply of wastepaper from post-consumer sources are desirable. The conclusions of EPA's studies are that wastepaper supplies can be obtained to meet significant increases in wastepaper demand, but such supply increases will call for innovative action on the part of secondary material dealers, communities, and paper users alike. Federal actions in this area–in the form of technical assistance services and planning assistance–appear to be appropriate at this time. EPA has developed extensive knowledge and data in this area as a consequence of detailed contract investigations, direct technical assistance work with communities, and interaction with the principal wastepaper consuming corporations. In the coming year EPA will undertake a technical assistance program to aid both communities and industry in developing and marketing wastepaper and supplies.

Given currently strong demand, a fiscal incentive program for paper recovery is not necessary at this time. To a significant extent, the use of incentive measures is predicated on the absence of demand for wastepaper or very high risks associated with investments in new wastepaper processing facilities. Today conditions indicate that demand is strong and growing, although there is no consensus in the field to indicate that demand will continue at the current rate.

Therefore, a fiscal incentive program for paper is not recommended because the risks are too great that public funds will be expended to support wastepaper consumption that is expanding for other reasons. However, there are considerable uncertainties in this volatile market area, and this recommendation should be reevaluated in coming months if new information becomes available. In this regard EPA will continue to actively monitor the wastepaper situation.

STEEL CAN RECYCLING

Statistical Overview

Ferrous materials constitute roughly 7 percent of municipal solid waste (excluding automobiles) and approximately 60 to 80 percent of this fraction is steel cans. It is estimated that in 1972 approximately 5 million tons of cans entered the solid waste stream. About 70 percent, or 3.5 million tons, were generated in SMSA's, where recovery should be possible.[11] The current recovery of cans from municipal solid waste is small. In 1972 approximately 70,000 tons of cans were recycled; and of this, 50,000 tons were consumed in one market, copper precipitation, which is exclusive to the western United States.[12]

Of major importance to can recycling is the fact that the "steel" can is in reality a composite can consisting of tin-plated steel (thus the term "tin" can) and possibly lead, organic coatings, and aluminum. More specifically, of the cans in solid waste, about 63 percent are tin-plated food and nonfood containers that have lead-soldered side seams. The other 37 percent of the cans are beer and beverage cans, three-quarters of which are also tin-plated and have soldered seams. (Roughly 22 percent of steel beverage containers are tinfree steel.) Most of the beer and beverage cans have aluminum tops to allow use of the easy-to-open pulltab. Taken as a composite, this can fraction contains approximately 92 percent steel, 0.4 percent tin, 1.5 percent lead, 3.7 percent aluminum, and 1.8 percent organic coatings.[13] Nonferrous residuals as high as these present serious metallurgical problems for the steel industry and also for certain other markets. This is the major reason can scrap is often considered to be "bad scrap." However, for some markets the residuals may be as valuable as the steel. In particular, the small quantity of tin in the 3.5 million tons of cans available in SMSA's would be worth almost $60 million, roughly one-half the total value of the steel in the cans.

Markets for Post-Consumer Cans

There are three major potential markets for old cans: the steel industry, the detinning industry, and the copper precipitation industry. (The detinning industry is really an intermediate processor, extracting tin from the cans and selling the detinned scrap to the steel industry.)

Steel Industry. Several steel mills have made promising and energetic efforts toward can recycling over the past 2 years. However, in 1972 the steel industry only consumed an estimated 11,000 tons of old cans.[11] This is a small amount relative to that industry's raw material inputs. Old cans have not been considered a desirable raw material by the steel industry in the past because of tin, aluminum, and lead residuals. These contaminants can cause either quality loss in the steel product and/or refractory damage to the melting furnace.

For steelmaking, tin is probably the most serious contaminant. Although specific estimates differ, it is generally accepted that extremely small quantities of tin on the order of 0.01 percent, 0.03 percent, and 0.05 percent should be the maximum quantity of tin allowable in medium-grade steel, plate steel, and reinforcing bars, respectively. Therefore, the maximum consumption of old cans by the steel industry on a national basis would be between 1.5 and 7.2 million tons per year because the furnace charge could contain only a small quantity of old cans. However, suitable supply arrangements and logistics would be required to achieve even this level of use. Widespread acceptance and consumption of old can scrap by the steel industry is possible but severely limited by a host of problems. Consumption is expected to grow, but at a very slow pace, over the next 10 years.

This situation is completely changed if the cans have first been processed through a detinning plant to remove (and recover) the tin. Detinned can scrap is readily marketed to the steel industry at or near the price of No. 1 heavy melting scrap.

Detinning Industry. Detinners chemically process tin plate to remove and recover tin. Detinned ferrous scrap is readily marketed to the steel industry. The tin, valued at about $4,000 per ton, contributes about one-third of the detinners' revenue, and the steel scrap sold accounts for the other two-thirds.

The detinning industry is not large. Two companies represent over 90 percent of the industry's sales. The industry presently processes a negligible quantity of post-consumer cans, obtaining most of its raw materials from can manufacturing scrap. In 1971, 752,000 gross tons of tin plate were processed, essentially the same as in 1950.[14]

The reason that more old can scrap has not been processed by detinners is largely because of contaminants. Entrapped organics, labels, paper, and plastics are all troublesome, as is lead. Aluminum (from bimetal cans) is by far the most serious contaminant and is the major deterrent to use of old cans by detinners. Aluminum can be removed by an additional processing step in the detinning operation, but it has been estimated that this would increase processing costs roughly $10 to $15 per ton. Thus, coping with the aluminum in cans is ultimately more of an economic than a technological problem.

Despite this added cost, it appears that detinning plants might still be able to expand capacity to handle post-consumer cans if supplies could be made available at $10 to $20 per ton, depending upon the market price for No. 1 bundles. To date, supplies of post-consumer cans have been difficult to obtain from municipalities, which do not generally attempt to recover and market these items.

It is also significant that altering the design of cans to eliminate the aluminum top would essentially alleviate the problem of detinning post-consumer cans. Chapter 4 presents a discussion of product control measures of this sort.

Copper Precipitation. Copper precipitation accounted for 50,000 of the 70,000 tons of recycled cans in 1972. Old cans represented approximately 10 percent of the 500,000 tons of scrap consumed by the industry in 1972.[15] This scrap was consumed in facilities in Montana, Nevada, Arizona, Utah, and New Mexico. These markets are obviously remote from major centers of waste generation in the midwestern and eastern United States. The market for "precipitation iron," as it is called by the industry, is expected to nearly double over the next 15 years; but the use of old cans in this context will be largely dependent upon getting supplies to these markets. Although it is a desirable outlet for old cans, copper precipitation is a very different form of can recycling. The steel is not actually recovered but is used in a chemical displacement reaction to precipitate copper. The potential for increased old can "recycling" in the copper industry is considered good, but moving very slowly.

Based on a recent study conducted for EPA, a subsidy of $6 per ton of post-consumer cans to the steel, detinning, and copper precipitation industries would result in a 9-million ton increase in the recycling of cans from 1976 to 1985.[16] (Extending the subsidy to the steel and copper precipitation industries would be virtually ineffective compared to its application to detinning and would have no predictable cost-effective benefits.)

The cost of this subsidy to the Federal Government would average about $6.5 million per year. Windfall, based on present levels of post-consumer can recycling, would be about 30 percent.

Supply of Post-Consumer Cans

Ferrous materials are relatively easy to extract from waste because they can be separated magnetically. However, there is presently very little post-consumer can scrap being extracted from solid waste.

In 1972, the American Iron and Steel Institute published a list of 17 cities magnetically separating ferrous material. However, many of these installations have not been successful, and many others are operating far below capacity, largely because of design problems. Shredding is required prior to ferrous material extraction, but shredders were often not properly designed for maximum efficiency, or the ferrous material was shredded in such a configuration that it was not acceptable for the local market. In many cases the ferrous product was dirty or contaminated, and thus not marketable.

It appears that shredding of waste for ferrous material extraction alone is not economical. At $20 per ton for cans and $12 for other miscellaneous ferrous materials, revenue from ferrous material extraction would total less than $1.25 per ton of refuse processed, hardly enough to cover shredding costs in almost any size facility.

However, refuse shredding is often justified in itself by virtue of densification for improved landfill efficiency or increased freight payloads where transfer stations are involved. In these instances, the incremental costs of ferrous material extraction should be easily covered by the revenues.

An excellent opportunity for ferrous material extraction is to be found in energy recovery or other types of comprehensive recovery facilities that are emerging. In all instances, shredding of waste is required; and in most of the energy recovery facilities, organics must be separated from inorganics to maximize burning efficiency. Ferrous material extraction is easily justified in these instances.

The fact that shredding is becoming more common as an element of solid waste disposal or recovery will lead to increasing potential opportunities for ferrous material extraction. If the planned systems are actually put into operation, there will be a marked increase in can supplies, which could exceed demand. This would occur if the cans were not properly shredded and prepared to meet the needs of particular markets, if markets for cans were not stimulated to some degree, and if buyers and sellers were not brought together. If demand did not rise to meet supply, the long-run impact would be a phasing-out of some can extraction operations.

Conclusions and Recommendations

The barriers to steel can recycling include both demand and supply constraints. The technological barriers to use of undetinned cans by the steel industry are obvious and will undoubtedly work to limit recycling through this channel even if price or cost relationships are altered or more abundant supplies are made available. Higher consumption in copper precipitation is promising, but limited by the location of the markets and the difficulty of transporting supplies to those market areas.

Detinning offers potential for steel can recycling. It upgrades the can scrap into a form of high-grade steel scrap and recovers a valuable resource, tin, which would otherwise be considered a contaminant. Also, the economies of scale of detinning plants are such that new small-scale plants could be built near cities or resource recovery plants where cans are generated.

Aluminum contamination is the major significant economic barrier to detinning of old cans. However, the present difficulty of obtaining reliable supplies is also an important consideration. Major expansion of the detinning industry will probably require that the economic burden of dealing with aluminum (or the aluminum top itself) be reduced and that new supplies of properly prepared scrap be made available.

Recommendations to stimulate steel can recovery, to the extent appropriate, must obviously respond to the barriers just discussed. One obvious need is to ensure adequate supplies of properly extracted and processed cans where markets exist. More and better information is needed by municipalities on the configuration and economics of optimum techniques for recovering cans from the waste stream, the necessary form and quality of the scrap to ensure its suitability for available markets, and appropriate means of establishing contacts with these markets. To a large degree, these needs could be met through proper communication between industry and municipalities. Bringing the supply and demand sectors together is believed to be an appropriate application of a Federal technical assistance and information dissemination program, and EPA will continue efforts in this direction in the future.

The type of action needed to stimulate demand is somewhat less clear. Some increased recycling through the steel, detinning, and copper precipitation industries could be expected to result from availability of a broader supply base even with no demand stimulation. However, the real key to long-term increases in can recycling is expansion of the detinning industry. It is presently questionable whether this industry would significantly expand capacity in the face of the additional $10 to $15 processing cost required to remove aluminum contaminants. Possible Federal actions for encouraging detinning expansion range from providing direct subsidies to offset the cost of removing the aluminum contaminant to establishing product controls to eliminate aluminum tops on beverage cans.

The ultimate decision of whether the Federal Government should consider such measures hinges primarily on two issues, both of which are difficult to resolve at present. One is the degree to which can recycling might increase with supply creation through a technical assistance effort. If a significant increase in recycling could be achieved by such a technical assistance effort, the added value of a subsidy would be small. The other major issue is the question of beverage container legislation. State programs such as Oregon's beverage container deposit law (see Chapter 5) could have the ultimate effect of sharply reducing the quantity of cans and other nonreturnable beverage containers in waste. This would eliminate the aluminum content of steel cans (because food cans do not contain aluminum) and make detinning of old cans more attractive. Beverage container and product control issues are discussed in detail later in the report.

GLASS, ALUMINUM, AND PLASTICS RECYCLING

Glass

Glass constitutes about 10 percent by weight of municipal solid waste and totaled approximately 11.6 million tons in 1971. Virtually all of this glass consisted of discarded containers and packaging. Beverage containers account for about half the total.

According to estimates of the Glass Container Manufacturers' Institute, in 1972 nearly 225,000 tons of post-consumer glass were recycled as the result of volunteer collection efforts, particularly community recycling centers. Other glass cullet consumed by the industry was primarily in-plant manufacturing scrap and cullet from bottling operations.

In terms of market suitability and potential demand, glass is an inherently recyclable waste material. Clean, color-sorted glass is an attractive raw material to the glass industry, and demand exists at prices comparable to virgin materials. No major process changes are required to utilize even very large quantities of waste glass (cullet) in glass manufacturing. Because use of cullet reduces fuel consumption and refractory wear, glass cullet is to some degree preferable to virgin materials.

Glass recycling is limited by supply. Glass is not easily removed from municipal waste. Home separation and separate collection of glass are possible and have been practiced, but only on a limited scale.

The best opportunity for removal of glass from waste is through mechanical separation in recovery facilities where waste is already undergoing shredding, air classification, or other types of separation. The separation of glass in such instances can generally be achieved, but the glass must also be color sorted to make it marketable. The technology for extracting and color-sorting glass is being developed and is currently in early stages of demonstration in conjunction with the EPA demonstration of the Black-Clawson Co. wet separation system in Franklin, Ohio.

The economic attractiveness of glass recovery is still not clear and may vary considerably depending on the type of processing employed in the recovery system. Recovery of glass is usually not based on an independent investment decision; separation of glass may be required to produce a clean organic waste fuel or may be undertaken to obtain aluminum, with a glass fraction occurring as a by-product. In the Franklin, Ohio, demonstration, for example, the projected economics of the combined aluminum and glass recovery look attractive, but primarily because of the value of the aluminum extracted with the glass. However, the small additional investment to color sort the glass after this initial processing also appears justified.

The proximity of markets is also an important influence on glass recovery economics. Glass recovered at a site more than 200 miles from a glass plant is unlikely to yield sufficient revenue to justify recycling.

Glass can also be used as a road-paving material or a component of building products. Such new uses are now being tested by various researchers. As a rule, however, the value of glass in such applications is much lower than its value as cullet.

The most reasonable conclusion to draw at this time is that glass recovery in some form will accompany at least the larger installations of energy recovery or other mixed waste processing systems. Measures that would eliminate nonreturnable beverage bottles could considerably alter the necessity or desirability of glass recovery.

Aluminum

Aluminum constitutes less than 1 percent by weight of municipal solid waste but comprises the bulk of nonferrous metals. The estimated quantity of aluminum in municipal waste is 800,000 tons a year. Current recovery of aluminum is estimated to be 80,000 tons. Most of this is being recovered in industry programs of separate collection through recycling centers.

Aluminum, like glass, is a valuable and desirable material for recycling from the standpoint of the user, in this case secondary aluminum smelters. The market price for secondary aluminum is $200 per ton, 10 times that of many other materials in mixed municipal waste. For this reason, aluminum recovery would make an important contribution to the revenue of a resource recovery system.

The major constraint to aluminum recycling is supply. Recovery through consumer separation efforts has been successful in some instances and after some years of such practice, it appears that these efforts are becoming institutionalized and will continue. Aluminum recovery has been considered in most large-scale recovery systems under development, but the actual separation process (heavy media separation in most instances) has not yet been demonstrated.

Aluminum recovery will be tested as a part of some of the resource recovery systems EPA is sponsoring. Aluminum recovery could also be significantly affected by beverage container measures eliminating the beverage can or the pulltab top. Developments in this area will be closely monitored.

Plastics

Plastics presently constitute approximately 3.8 percent of municipal solid waste, but plastic consumption is growing rapidly. Essentially no recovery of plastics as a material from mixed waste now takes place.

Of all the materials in mixed waste, plastics are probably the most difficult to extract. Recycling of certain plastic wastes from fabrication plants is practiced. In industrial plants it is possible to keep different types of plastics (e.g., polyethylene, polystyrene, and polyvinyl chloride) separated at the source. Once plastics have entered use, and especially after they have been discarded into the waste stream, they are extremely difficult to separate.

Supply of waste plastics is simply not possible with existing technology because plastics cannot be separated from paper and other materials in mixed waste with similar physical characteristics. Experiments have been conducted with new separation techniques but are a long way from full-scale application.

Significant value may be recovered from plastics in energy recovery systems. Plastics have the highest British thermal unit content of any of the materials in mixed waste and thus make a valuable contribution to the heat value of the waste. The heat content of plastics is about 11,000 British thermal units per pound, approximately the equivalent of coal.

The only potential difficulty with recovery of energy from plastics is the presence of polyvinyl chloride, a small proportion of total plastic production (13 percent) and hence an even smaller proportion of solid waste (0.42 percent). However, when burned, it emits hydrogen chloride, a toxic gas. When this gas is combined with moisture, as in the wet scrubbing sections of incinerator emission controls, hydrochloric acid is formed, which will corrode the metal parts of the control equipment and other metal incinerator parts, resulting in increased maintenance costs and potentially increased air pollution emissions. In addition, the water discharged from these scrubbing systems has a low pH and would present a threat to natural waters if not properly treated.

Conclusions and Recommendations

The major barriers to aluminum and glass recovery are related to the economical extraction of these materials from mixed municipal wastes. Once extracted, there is sufficient demand to facilitate significant increases in recycling of these materials. Technology is under development for aluminum and glass recovery but has not proven to be economically feasible to date. Beverage container control legislation could significantly impact on the need or prospects for aluminum and glass recovery in the future. EPA will continue to monitor developments in this area and will provide technical assistance and information.

The most logical approach to plastics recovery is as an energy source because currently it is not technically feasible to separate plastics from mixed wastes in an economical manner. However, the polyvinyl chloride fraction could pose significant environmental problems, especially if this fraction grows significantly in the future. EPA will continue to monitor trends in this area and make recommendations as necessary to insure the prospects for environmentally sound energy recovery.

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Chapter 4

PRODUCT CONTROLS

The term "product control" may be defined broadly to include any public policy measure directed at regulating either the volume of sales (quantity) or the physical design characteristics* (quality) of specific products or groups of products supplied for domestic consumption. (As used here, the term "product" can apply either to a final item of manufacture, such as an automobile or a beverage container, or to an intermediate product, such as a refined metal.) Historically, U.S. experience with product controls has been most extensive in the fields of foreign trade (i.e., import tariffs and quotas) and product health and safety regulation (e.g., food, drugs, flammable materials, and automobiles). Recent examples in the field of environmental protection include Federal regulations on the production and use of pesticides, Federal product noise standards, and State standards on the maximum sulfur content of fossil fuels.

In the specific context of solid waste policy a wide variety of product control proposals have been made. Some of the more significant of these include a (1) weight-based tax (e.g., penny-a-pound tax) on consumer goods, (2) taxes and/or bans on specific types of plastics (e.g., polyvinyl chloride), (3) bans on pulltab beverage cans, (4) bans on bimetallic cans, (5) restrictions on the use of copper in automobiles, (6) development of standards for durability of consumer appliances, (7) bans or taxes on throwaway convenience items, (8) environmental degradability standards for certain goods, (9) regulations governing the minimum recycled material content of products (typically paper products), (10) mandatory deposit requirements for beverage containers.*

Even within the solid waste field, the list of all possible product controls that might be conceived is almost infinite because there are a great many product attributes that might be targeted for regulation, and there are also usually a large number of alternative policy tools for achieving given objectives. Thus, the field is extremely complex, and the present chapter can provide only a cursory introduction to a subject that has only recently come under close investigation.

As with other forms of intervention into the private market system, product control policy draws its theoretical justification from the failure of private market decisions to achieve maximum social welfare. Economists have long argued that "overconsumption" of particular materials and products will result whenever the full social costs of production are not internalized in the market price of products. While some economic incentives exist to conserve resources (e.g., rising material and energy costs), it has been suggested that the social costs of pollution and other environmental damages (associated with various stages of product production, consumption, and post-consumer waste disposal) represent evidence of private market failure to adequately reflect and balance social priorities. A basic question is whether private market processes can be relied upon to systematically evolve socially optimal product designs, including adequate consideration of such factors as product durability, repairability, waste

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*Appendix B presents a conceptual discussion of the significance, technical feasibility, and potential impact of a wide variety of product design modifications for source reduction, resource recovery, and waste disposal purposes.

*Mandatory deposit laws are in effect in both Oregon and Vermont. See Chapter 5 for further discussion.

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disposal costs, and ease of material recovery from obsolete or discarded items. Little or no theoretical or empirical economic analysis exists on the subject of the social efficiency of product design. General observations raise some questions regarding product design from a solid waste generation/disposal/recovery perspective; and these provide evidence of need for more detailed consideration of product control possibilities.

In this chapter, product controls are considered in the two separate but related contexts of source reduction and resource recovery. Source reduction is concerned with reducing the generation of solid waste by such means as reducing the material intensivity of products; increasing product durability, lifetime, or reuse; and possibly banning or reducing the volume of consumption of certain products. Product controls to achieve resource recovery can involve improving the recyclability or increasing secondary material content of products to enhance both technical and economic feasibility of recovery.

Two general categories of policy tools are applicable in the product control area: direct regulatory measures and fiscal approaches. These tools can be used for both source reduction or resource recovery purposes. Source reduction regulations, for example, might include setting standards for minimum product lifetime or banning the manufacture of throwaway products. Regulations for resource recovery might include bans on the bimetallic can to improve steel recycling or setting recycled material content specifications for paper products to increase secondary fiber demand. Fiscal measures also apply to source reduction, such as discriminatory taxes on certain products or materials. Fiscal measures to encourage resource recovery include monetary incentives for the use of secondary materials as discussed in Chapter 3.

The major implementation options available are (1) to institute broad-based taxes or other financial incentives designed to internalize waste management costs,* letting the market system make the appropriate adjustments; (2) to tax or impose deposits on specific products having a significant source reduction or resource recovery potential; (3) to regulate directly certain physical characteristics of all products; (4) to regulate selected products or material components having potentially significant source reduction or resource recovery benefits; (5) to combine regulatory and fiscal measures into a comprehensive source reduction/resource recovery approach.

The selection of a strategic product control option has important consequences in that it establishes the philosophical basis of the approach. Selective approaches, where intervention is by exception, are designed to solve a particular recognized problem and do not attempt to resolve general problems that are reflected in many products. Selective regulations or incentives are relatively easy to implement because they single out a particular problem as it occurs in relation to a specific product. Broad approaches, on the other hand, are directed toward the resolution of issues affecting most or all manufactured products, such as the possible undervaluation by the private market system of virgin raw materials because of the failure of supply prices to include the full social costs of material extraction and processing. Because of their breadth, they are far more cumbersome to implement or are less precise in their effects. They rely either on market forces, which may be poorly understood, or they necessitate a large, unwieldy administrative structure to implement.

PRODUCT CONTROLS FOR SOURCE REDUCTION

Source reduction has been defined as the reduction of post-consumer solid waste generation either by altering the basic design, lifetime, or use pattern of particular consumer goods or by changing the composition of sales in such a way as to reduce the waste volume associated with a given level of aggregate consumer demand. Thus defined, source reduction could conceivably be achieved by methods other than product controls. These might include educating or persuading consumers to change their fundamental consumption habits or imposing waste disposal charges at the point of waste generation as an indirect means of influencing consumer purchase and product use decisions. EPA studies to date have been directed toward possible product control options for achieving source reduction objectives. One of the main reasons for this choice is that a very large number of product control proposals are currently under consideration by Federal and State legislatures. This section discusses the products that may be selected for source reduction purposes and the mechanisms that may be utilized for achieving source reduction goals.

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*Appendix C presents a discussion of a specific product control designed to internalize the costs of solid waste management.

Selection of Products for Source Reduction

Substantial difficulties arise in evaluating and selecting products for source reduction. One such difficulty concerns the level of specificity at which the product control should be placed. Should such a control encompass all nondurable products, a specific product class (e.g., packaging), or an individual product (e.g., beverage containers and paper towels). The greater the level of detail, the more manageable the individual control measure and the more clear are the effectiveness and costs of particular actions. But focusing on particular products raises equity issues when other products possess similar characteristics and makes the overall job harder because many more separate judgments have to be made.

In evaluating products for source reduction, the following criteria appear relevant:

(1) If a product is composed of scarce material, consider the substitution of a product composed of abundantly available materials.

(2) If a product causes difficulties in disposal, consider the substitution of a product the disposal of which would be less difficult.

(3) If a product has a short lifetime, consider the substitution of a product with a longer lifetime.

(4) If a product is not reused, consider the substitution of a reusable product.

(5) If a product's material consumption has grown without corresponding growth in the service the product delivers, consider the substitution of a less material-intensive product.

(6) If product manufacture is energy or pollution intensive, consider the substitution of a product that is less energy or pollution intensive.

In all cases, in application of these criteria, consideration should be made as to whether market prices currently reflect full social costs and whether other social control options may not be able to achieve the same ends in a more efficient and/or equitable manner. Care must also be taken to avoid the unnecessary introduction of other undesirable market distortions into the market decision processes. A major research effort is currently underway that will attempt to analyze all major products in solid waste in relation to all or some of these criteria.

Mechanisms To Achieve Source Reduction

There are four major types of mechanisms applicable to source reduction: taxes or charges, deposits, bans or quotas, and design regulation. Evaluation of these options requires analysis of the ability of the option to achieve a desired end result, analysis of the economic impacts on producers and consumers, analysis of environmental and social impacts, and a determination and assessment of overall costs and benefits.

Product Taxes or Charges. Product taxes or charges could be used for source reduction purposes in several ways. For example, product charges based on the weight of a product (in order to provide an incentive for weight reduction) have been suggested. (See Appendix C.) Other examples include charges based on product lifetime or charges on a particular use of a material. These are fairly broad-based measures applicable to wide classes of products. Therefore, determining the appropriate level of the charge and predicting effectiveness and impacts are complex and difficult tasks.

Deposits. Deposits, designed to encourage product reuse, may be effective source reduction measures; however, they are only of value when a reuse or return system exists. Thus, deposits may apply in the beverage container area where reusable containers are available or for tires when retreading could take place. Deposit measures are thus limited in scope and may be viewed as viable measures only where reusable products are available. A detailed discussion of beverage container deposit systems is provided in Chapter 5.

Bans. Bans could be used as product controls for source reduction if material or product substitutions were desirable. They could generally be applied only if alternative materials and products exist. For example, bans on polyvinyl chloride containers could be instituted only if other containers are available. This mechanism, like the deposit, is thus also somewhat limited in scope and could only be used on a selective basis.

Design Regulation. From a source reduction perspective, design regulation could be applicable to the extension of the lifetime of specific products as well as to the design of products for reuse or decreased resource intensivity. This mechanism implies that a regulatory authority would specify the design parameters for specific products. This would require extensive research into product design and a fairly extensive bureaucracy for administration.

To further analyze product control mechanisms for source reduction, two studies are currently being undertaken. In the first of these, product-by-product regulatory approaches relating to existing Federal programs in product health and safety are being analyzed to assess the administrative requirements and potential effectiveness of direct product regulation. A second study to determine the demand elasticities of major products in the solid waste stream is expected to provide data on the potential effectiveness of fiscal measures for source reduction. These studies should assist in the evaluation of product control measures to reduce resource consumption and waste generation.

PRODUCT CONTROLS FOR RESOURCE RECOVERY

Product control approaches for resource recovery could increase the recyclability of products by making it easier (less costly) to separate and recover high-quality secondary materials and could establish product specifications requiring the use of secondary material inputs. As in the case of source reduction product controls, two issues are raised: selection of the products to be controlled and the types of mechanisms that might be utilized.

Product controls for recyclability are concerned with eliminating materials or product configurations that inhibit recycling or increase the cost of resource recovery. Cases where recyclability is a particular issue include the bimetallic (steel-aluminum) can; rubber tires with tungsten studs, which do not separate by magnetic means; aluminum rings around glass bottles; and copper content of automobile scrap.

With respect to product controls for secondary material content, all major products could be theoretically considered for control. However, there are technological limitations (for example, in plastics recycling), material supply problems, and product performance considerations that constrain this approach.

There are two major types of regulatory mechanisms applicable to resource recovery product controls: bans and standards. Fiscal incentive approaches are discussed in Chapter 3. Bans could be utilized to remove nonrecyclable product configurations from the marketplace or eliminate virgin material use in particular products. Standards could be utilized to set minimum secondary material use specifications. In the form of a general mandate covering all products, this latter mechanism would require analysis of all products to determine component material and design potentials. Such an analysis would be an extremely complex project. Enforcement of such standards would require establishment of a large administrative structure. If the standards were selective, on the other hand, administrative problems would diminish substantially but equity problems might arise.

The current experience of the General Services Administration is significant in a discussion of this type of product control. (See Chapter 2.) The General Services Administration experience with secondary fiber specifications in paper products has been very valuable in establishing the requirements and procedures for product controls for recycled material content.

CONCLUSIONS AND RECOMMENDATIONS

The concept of product controls to conserve resources, reduce environmental damage, and reduce the burden of disposing of solid wastes is one that should be carefully considered. There could be important benefits derived from product controls that impact on producers and consumers in an equitable manner (i.e., in proportion to their contribution to environmental problems) and result in increased overall efficiency of resource utilization, pollution control, and waste management.

On the other hand, product controls could have profound impacts on the market system because they involve direct control of product design or consumption levels. The effect of these measures is difficult to predict, and hasty action could result in significant economic dislocations. For these reasons, it is important to proceed very cautiously in this area and to consider options that are reasonable, fair, and equitable.

At present, there is insufficient information to evaluate the necessity or desirability of product control measures. Therefore, to be able to make appropriate recommendations to the Congress in this area, it is recommended that EPA, as part of its research and analysis program, continue to study product controls for resource recovery and source reduction purposes. Several such studies are currently underway.

Chapter 5

STUDIES OF RESOURCE RECOVERY AND SOURCE REDUCTION OF SPECIAL WASTES

EPA has been conducting special investigations of the disposal, recovery, and source reduction of particular products that enter the solid waste stream. This chapter presents a review of the status of these studies for four products: automobiles, packaging, beverage containers, and tires. These products were selected for study for the following reasons:

(1) *Automobiles.* Obsolete automobiles generally never enter the mixed municipal waste stream and are processed, discarded, and recycled separately from other products. A significant number of automobiles are discarded in an uncontrolled manner – abandoned. Therefore, special studies of strategies for preventing abandonment and increasing recycling of automobile scrap were undertaken.

(2) *Packaging.* Packaging waste represents the largest single product class in the municipal waste stream (34 percent), and packaging material consumption has been growing at a rapid rate. Therefore, evaluation of various source reduction measures for controlling packaging waste was considered appropriate.

(3) *Beverage containers.* Soft drink and beer containers were singled out from other packaging products for special analysis for several reasons. First, many beverage containers are discarded in an uncontrolled manner; such containers represent a substantial fraction of roadside litter. Second, the refillable bottle represents an existing technical option for achieving source reduction of beverage containers. Therefore, various approaches to reduce beverage container litter and institute refillable container systems were studied.

(4) *Tires.* Although automobile tires only represent a small percentage of municipal solid waste, they are difficult to dispose of either by incineration or landfill. In addition, many tires are not discarded with other wastes but are accumulated at tire retailers and disposed of separately. Rubber tire recycling and retreading are a few of the options that are being studied for dealing with this special waste.

Because EPA's studies in these areas are still underway, the conclusions and program directions that are presented in the following sections are of a preliminary nature.

AUTOMOBILES

Disposition of obsolete automobiles can take several forms as indicated in Figure 1. The automobile wrecking industry acquires discarded vehicles for spare part value and sells the stripped hulks to scrap processors. Most retired vehicles that enter the scrap cycle follow this route. A small percentage of vehicles that are very old, or have no part value, are conveyed directly to scrap processors by their final owners. Some cities designate disposal sites where obsolete vehicles are accumulated prior to shipment to wrecker, or processor, or where vehicles are disposed of by landfill.

Obsolete vehicles are abandoned when the owner does not know another means of disposal or if he is unwilling to incur the cost of delivering the vehicle to a disposal site, automobile wrecker, or scrap processor. Automobiles that are abandoned on public roadways are generally collected because they present traffic problems or hazards. Vehicles that are abandoned in remote locations or in locations with difficult access are generally not collected.

There are three basic environmental and social problems that result from improper disposition of obsolete automobiles:

(1) The degradation of the aesthetic quality of the physical environment caused by abandoned vehicles (This is essentially a litter problem causing considerable public annoyance.)

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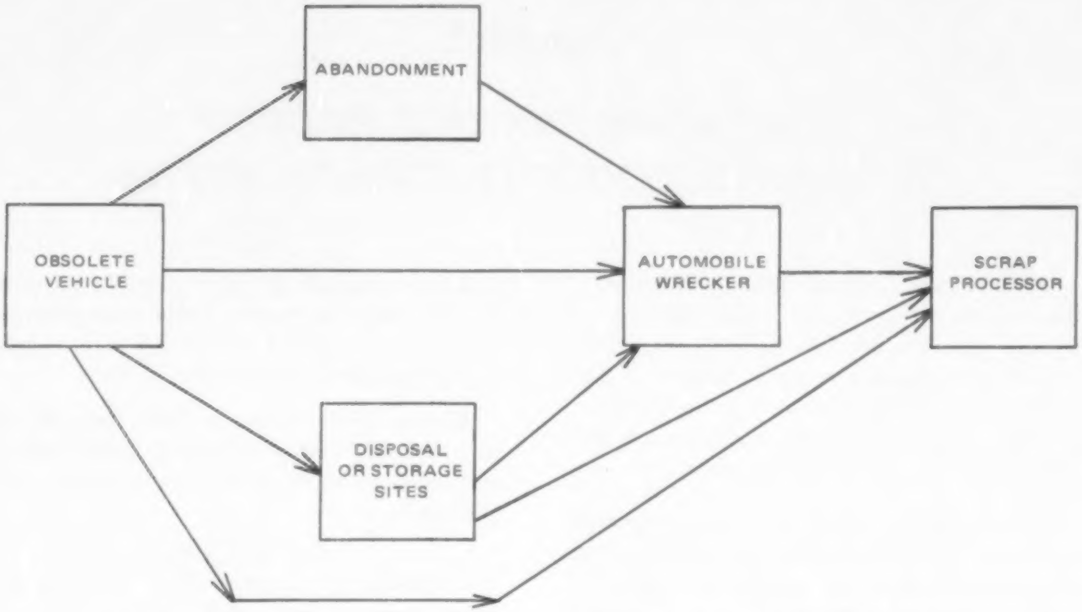

Figure 1. An obsolete automobile may follow one of several paths on the way to becoming processed scrap.

(2) The financial burden imposed on the general public for collection of abandonments (This is an inequitable situation because the collection costs are not borne by the abandoner.)

(3) The aesthetic, resource consumption, and environmental consequences of the failure to recycle obsolete automobiles (This is an aesthetic problem in that vehicles that are not recycled accumulate in automobile wrecker yards or storage sites that are popularly referred to as "auto graveyards." In addition, such vehicles also represent an untapped resource that if recycled would reduce consumption of virgin resources and reduce the environmental damages caused by virgin material mining and processing.)

In the following sections automobile recycling and abandonment problems will be discussed in more quantitative terms, barriers that impede automobile recycling will be identified, and measures to prevent abandonment and facilitate recycling will be evaluated.

Automobile Recycling

Table 39 presents the metals recoverable from obsolete automobiles. Steel is the primary component. Steel scrap can be processed in three different ways prior to recycling; it can be (1) baled into No. 2 bundles (removal of the engine, seats, and gas tank and compression of the hulk into a block), (2) slabbed (slicing flattened automobile bundles into slabs), (3) shredded (shredding of automobile hulks and magnetic separation of ferrous fraction).

The first two processes produce a low-value contaminated steel scrap, while the third process generally results in a high-value material for which there is considerable demand. It is estimated that in 1972 approximately 4.4 million tons of bundled automobile scrap and 3.3 million tons of shredded automobile scrap were processed in the United States.[1]

Figure 2 shows two estimates of the historical consumption (domestic plus exports) of processed automobile hulks (the difference in these estimates is due to various assumptions made concerning the composition of automobiles and the percentage of automobile scrap in total bundled steel scrap). Also plotted on Figure 2 is an estimate of the annual automobile retirements. The difference between the retired and processed vehicle figures represents the vehicles that were not processed through the scrap

TABLE 39
VALUE OF RECOVERABLE METALS IN COMPOSITE AUTOMOBILE, 1972

Metal	Weight[*] (lb)	Price[†] (dollars)	Value (dollars)
Steel	2,614.0	25.00-38.00[‡] (per ton)	32.68-49.67
Cast iron	429.3	55.00 (per ton)	11.81
Copper:			
Radiator stock	15.4	0.25 (per pound)	3.85
No. 2 heavy and wire	13.8	0.32 (per pound)	4.42
Yellow brass solids	2.7	0.23 (per pound)	.62
Zinc, die castings	54.2	0.04 (per pound)	2.17
Aluminum, cast, etc.	50.6	0.12 (per pound)	6.07
Lead:			
Battery	20.0	1.40 (per battery)	1.40
Battery cable dumps	.4	0.11 (per pound)	.04
Total			63.06-80.05

[*] Dean, K. C., and J. W. Steiner. Dismantling a typical junk automobile to produce quality scrap. U.S. Bureau of Mines Report of Investigations 7350. [Washington], U.S. Department of the Interior, Dec. 1969. p.17.

[†] Typical secondary material prices from *Secondary Raw Materials,* 10(10):123-125, Oct. 1972.

[‡] $25.00 per ton is the price as a No. 2 bundle (crushed flattened hulk); $38.00 per ton is an estimate of the price of shredded and magnetically separated automobile steel—comparable to No. 1 heavy melting scrap.

cycle in a particular year. Estimates of the accumulation of these vehicles (in wrecker yards, storage sites, and uncollected abandonments) are presented in Figure 3.

One striking feature of Figure 3 is the range of estimates for the accumulation of unprocessed vehicles, from 8 to 19 million in 1970. This indicates that there is considerable uncertainty as to the magnitude of the unprocessed vehicle problem and the rate of growth. The average backlog of unprocessed vehicles was 12.75 million in 1970. Application of the Bureau of Mines estimate of the distribution of unprocessed vehicles yields a distribution for 1970 of 9.9 million vehicles in the automobile wrecking vehicle inventory and 2.85 million vehicles in the inventory of uncollected abandonments.[2]

Any consideration of the magnitude of raw material value forgone in unprocessed automobiles must be considered relative to overall steel production. In 1970, total raw steel production was 131.5 million net tons, and the total steel content in the estimated uncollected abandoned automobile backlog as of 1970 would amount to less than 3 percent of raw steel production. If automobile wrecker inventories are included, this percentage increases to around 13 percent.

In addition to steel, there are other raw material resources to be realized from recycling automobiles. Table 39 presents those estimated quantities and values at 1972 prices. If the steel value is calculated on the basis of No. 2 bundled steel at $25 per ton, a value of $32.68 per automobile results. This would make the total value of recoverable resources $63.06. Shredded automobile scrap sells at a price comparable to No. 1 heavy melting scrap ($38 per ton) and results in a vehicle metallic value of $80.05. Because of the higher value of shredded scrap (as compared to No. 2 bundles), the significant growth in automobile recycling has taken place in this form. To evaluate the barriers to increased steel recycling, the current market structure of the wrecker and shredder industries will be discussed.

Automobile Wrecking Industry. There are presently about 15,600 automobile wreckers in the United States that are the depository for 80 percent of the retired vehicles. The majority acquire and inventory automobiles for their spare part value if the cost of acquisiton is less than the value of spare parts contained in that automobile. After recovery of the parts, the hulk becomes dead inventory and eventually is sold to a scrap processor.

The wrecker's decision to sell the dismantled hulks, and often hulks that have some spare part

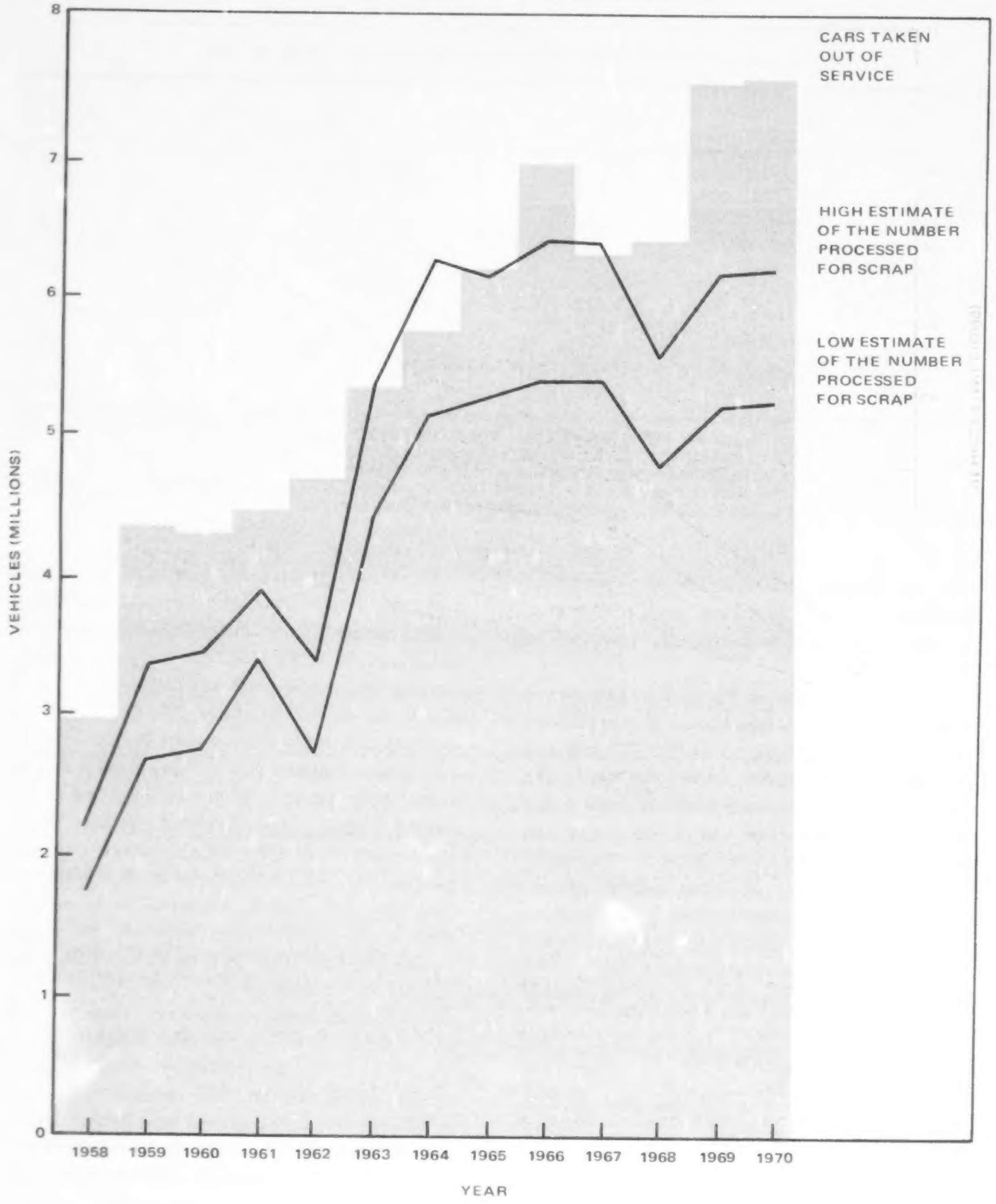

Figure 2. The difference between the number of cars removed from service and the number processed for scrap represents the number that did not go through the scrap cycle in that year. [Source: Booz-Allen Applied Research, Inc. An analysis of the abandoned automobile problem. U.S. Environmental Protection Agency Contract No. 68-03-0046, June 1972. (Unpublished data.)]

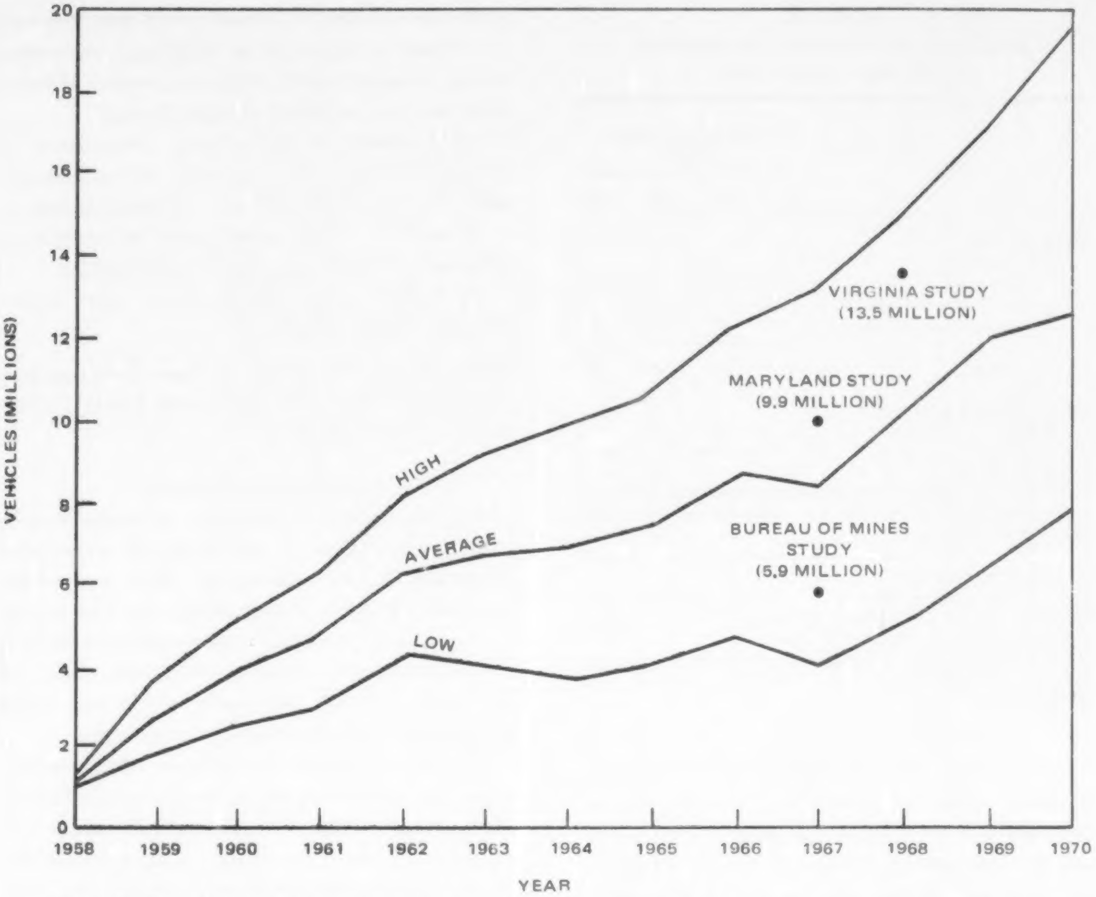

Figure 3. The estimates of the accumulation of retired vehicles not processed into scrap vary considerably. The three data points represent surveys in Virginia and Maryland and a survey in selected cities by the Bureau of Mines that has been scaled up to national proportions. [Source: Booz-Allen Applied Research, Inc. An analysis of the abandoned automobile problem. U.S. Environmental Protection Agency Contract No. 68-03-0046, June 1972. (Unpublished data.)]

value, depends upon the current price being offered by a processor, the size of the inventories and yard space requirements, and the location of the processor. Table 40 shows estimates of the costs to a wrecker to prepare and sell automobile scrap. These calculations illustrate that it would be profitable to ship hulks to processors up to 150 miles away, providing the price received is at least $25 per hulk, while it would not be economical to ship the hulks more than 150 miles. Differences in local transportation costs and prices will result in different economic transportation distances across the Nation.

Automobile Shredders. According to the Institute of Scrap Iron and Steel, there are over 100 automobile shredders operating in the United States with a total installed capacity estimated to be over 5 million tons annually. In 1969 there were 69 shredder plants; this is a growth of more than 45 percent within 4 years. The national average capacity utilization in 1972 was approximately 65 percent.

The map in Figure 4 shows current shredder locations. Also in this figure an estimate of the transportation radius for economic shipment of hulks (150 miles) is indicated, and it can be seen that in the eastern part of the Nation and on the West Coast shredders are available. In the midwest and northwest areas there are few shredders. Automobile registrations in these States constitute a minor portion of

TABLE 40
ESTIMATED WRECKER COST TO PREPARE AND SELL AUTO SCRAP

Item	Distance to processor (miles)			
	50	100	150	200
Costs (dollars):				
Stripping[*]	5	5	5	5
Flattening[†]	5	5	5	5
Transportation[‡] ($0.10 per vehicle per mile)	5	10	15	20
Total	15	20	25	30
Revenue from sale of hulk[§] (dollars)	25	25	25	25
Profit (dollars)	10	5	0	-5

[*] Special report on the auto wrecking industry. *Scrap Age*, 27(2):203. Feb. 1970.

[†] Private communication with the president of Mobile Auto Crusher Company.

[‡] Automobile disposal; a national problem. U.S. Bureau of Mines Special Publication No. 1-67. Washington, U.S. Government Printing Office, 1967. 569 p.

[§] Price received at processing plant is $1.25 per 100 pounds. Average stripped vehicle weight was assumed to be 2,000 pounds.

total U.S. registrations; however, because of absence of readily accessible automobile shredders, retired automobiles could be accumulating in wrecker yards, and abandonments could lie uncollected. The cumulative effect of many years of automobile retirements could be substantial.

Table 41 presents the estimated costs of operating a shredder; the total costs range from $32 to $46 per hulk. For steel prices in the range of $40 per ton to $50 per ton, hulk shipments could be received from long distances, wrecker inventories could be reduced, and it would be more economical to collect and transport abandoned vehicles. For steel prices in the range of $30 per ton to $40 per ton, shipment distances would be shorter. Therefore, movement of automobile hulks through the scrap cycle ultimately depends on maintaining a high price for steel scrap. There are several developments that could markedly affect this price:

(1) Technological developments within the steel industry might alter the overall quantity of scrap consumed. For example, use of prereduced ores in scrap-intensive electric furnaces would tend to reduce the demand for scrap. On the other hand, continuous casting processes would reduce the amount of home scrap generated and hence increase demand.

(2) A change in the material composition of automobiles could affect the value of the discarded hulk. Fuel shortages and air pollution regulations could result in a trend toward lighter vehicles and use of lighter materials (e.g., plastics or aluminum).

(3) Foreign scrap markets could exert strong influence over scrap prices.

These developments should be closely monitored and analyses be made to determine their potential effect upon automobile recycling.

Automobile Abandonment

The Department of Commerce estimated that in 1965 approximately 10 percent of all automobiles retired annually were abandoned.[3] Other studies have estimated the yearly abandonment rate to be as high as 15 percent.[4] Applying these percents to the 6.1 million automobiles retired in 1970 yields a range of 610,000 to 915,000 abandonments that year. Table 42 presents abandonment projections to 1980.

Not all abandoned automobiles remain uncollected. A study completed by the Bureau of Mines in 1967 estimated that about 20 percent remain uncollected and contribute to the accumulated backlog of uncollected abandoned automobiles.[5] An EPA study indicated that the number of these uncollected automobiles could range up to 30 percent of annual abandonments.[6]

With the use of a 25-percent uncollected abandonment figure, it is projected that between 1970 and 1980, approximately 2 million automobiles will be added to the uncollected backlog. The result will be approximately 5 million automobiles lying derelict (Table 43).

Location of Abandoned Vehicles. Limited empirical data collected by the Department of Commerce in 1965 indicate that most automobiles abandoned in the cities are left on public property and are collected.[5] This seems logical because cities would tend to remove abandoned vehicles that interfere with traffic or present hazards to the general public. For the most part, then, the backlog associated with uncollected abandoned automobiles is

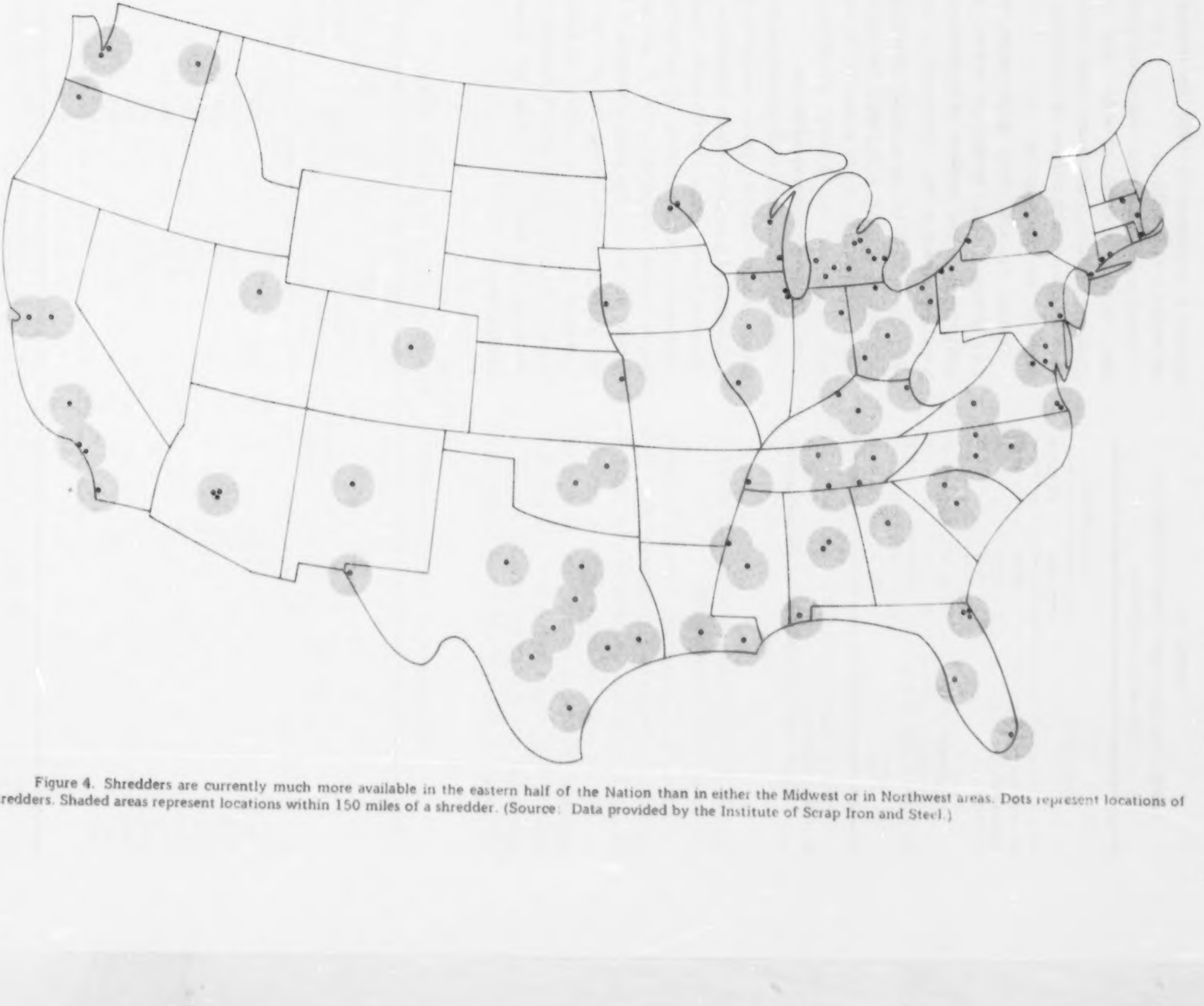

Figure 4. Shredders are currently much more available in the eastern half of the Nation than in either the Midwest or in Northwest areas. Dots represent locations of shredders. Shaded areas represent locations within 150 miles of a shredder. (Source: Data provided by the Institute of Scrap Iron and Steel.)

TABLE 41
ESTIMATED SHREDDER COSTS TO PREPARE AND SELL AUTO SCRAP*

Type of cost	Cost (dollars)	
	Minimum	Maximum
Price paid for hulk[†]	20.00	25.00
Transportation	5.00	10.00
Shredding	6.00	10.00
Subtotal	31.00	45.00
Fee (if sold through broker)	1.00	1.25
Total	32.00	46.25

*Source: Private communication with automobile shredder processors.

[†] It is assumed hulk is delivered stripped and flattened.

believed to be primarily a problem that occurs in rural areas and on private property.

Costs to Eliminate Backlog. The costs for picking up abandoned hulks and transporting them to a disposal site have been estimated to range from $10 to $25 but could be much higher in particular instances. Table 44 shows that with collection and disposal costs ranging from $10 to $25 per automobile, the total cost to eliminate the backlog in 1970 would be $28 to $72 million. If the backlog is allowed to accumulate to 1980, the cleanup cost will be $50 to $125 million.

Strategies To Deal with Abandoned Automobiles. There is a variety of actions that can be considered to clear up abandoned vehicle backlog or prevent future abandonments. The following paragraphs describe some examples.

Punitive Measures. Most States presently have laws making it illegal to abandon automobiles on public property, and the threat of a high fine may be a suitable deterrent. The effectiveness of such an approach is dependent upon public prosecution of offenders; if litigation is successful and publicized, casual abandonment may be prevented. The costs of such an approach would mostly be administrative costs to locate and prosecute offenders.

Disposal Certification. With this scheme an owner taking a vehicle out of service would be denied registration of another vehicle or required to pay a fine upon failure to prove that the retired vehicle was transferred to another individual or disposed of in a proper manner. The effectiveness of this measure depends entirely on how well the program is administered. With rigorous monitoring and with special provisions to handle out-of-State transfers, this measure could be very effective in preventing future abandonments. However, it does not address the existing uncollected backlog.

TABLE 42
ESTIMATES OF AUTOMOBILE PRODUCTION, RETIREMENT, AND ABANDONMENT, 1970-80*

Year	Automobiles (millions)					
	Produced	Retired	Minimum abandoned[†]	Maximum not abandoned of those retired[†]	Maximum abandoned[‡]	Minimum not abandoned of those retired[‡]
1970	8.2	6.1	0.610	5.490	0.915	5.185
1971	10.6	6.8	.680	6.120	1.020	5.780
1972	10.8	7.0	.700	6.300	1.050	5.950
1973	10.9	7.2	.720	6.480	1.080	6.120
1974	11.1	8.2	.820	7.380	1.230	6.970
1975	11.3	8.4	.840	7.560	1.260	7.140
1976	11.5	8.7	.870	7.830	1.305	7.395
1977	11.7	9.1	.910	8.190	1.365	7.735
1978	11.9	9.3	.930	8.370	1.395	7.905
1979	12.1	9.7	.970	8.730	1.455	8.245
1980	12.3	9.9	.990	8.910	1.485	8.415
Total	122.4	90.4	9.040	81.360	13.560	76.340

*Source: Production and retirement figures from the U.S. Department of Transportation Federal Highway Administration.

[†] Based on the estimate that 10 percent of the automobiles retired in a given year are abandoned.

[‡] Based on the estimate that 15 percent of the automobiles retired in a given year are abandoned.

TABLE 43
INVENTORY OF UNCOLLECTED ABANDONMENTS

Year	Obsolete automobiles (millions)		
	Abandonments (10 percent abandonment rate)	Uncollected abandonments*	Inventory of uncollected abandonments†
1970	0.610	0.150	2.850
1971	.680	.170	3.020
1972	.700	.175	3.195
1973	.720	.180	3.375
1974	.820	.200	3.575
1975	.840	.210	3.785
1976	.870	.215	4.000
1977	.910	.230	4.230
1978	.930	.230	4.450
1979	.970	.240	4.690
1980	.990	.245	4.935
Total	9.040	2.245	

*Assuming 25 percent of abandonments remain uncollected.
†Based on a 1970 starting inventory of 2.85 million automobiles.

TABLE 44
COST TO ELIMINATE ABANDONED AUTOMOBILE BACKLOG

Year	Estimated number of uncollected abandoned automobiles (millions)	Cost per automobile (dollars)	Total cleanup cost (millions of dollars)
1970	2.85	10	28.5
		15	43
		25	72
1980	4.9	10	49
		15	75
		25	124

The costs of a disposal certification system are all administrative—estimated at $0.04 to $0.08 per vehicle registration.[7] For 1970 the total national cost would be $3 to $7 million; for 1980 it would average $4 to $9 million. Some savings would be realized by not having to collect abandoned automobiles.

Deposits. With this measure a $25 to $50 deposit would be included in the selling price of the automobile and refunded in full to the final owner or automobile wrecker by the scrap processor. This measure could be effective in preventing abandonment as the intrinsic value of an automobile would be increased up to $50—more than most collection and disposal costs. It would also provide an incentive to reduce the vehicle inventory stored by automobile wreckers.

The major disadvantages of this measure are that it is inequitable in that 100 million automobile owners would be forced to bear the burden of less than 1 million abandoners and the measure is regressive in that a relatively greater burden is placed on individuals with low incomes who tend to purchase low-priced used cars.

Initial outlay for a national deposit program ($50 per vehicle) in 1970 would have been about $4.5 billion. Annual interest forgone on the deposit would be about $260 million. In addition, estimated annual administrative costs to run the program would be $2 to $10 per car or $16 to $80 million for 1970.[8]

Free Disposal Sites. This strategy would establish free disposal sites where unwanted vehicles would be accepted for storage prior to transfer to scrap processors. This could be effective in preventing abandonment that occurs because there is no alternative way to dispose of a vehicle. The effectiveness depends on the number and location of the sites. However, the cost barrier to transporting a vehicle to a site would still exist, and the only incentive to use the sites is the vehicle owners' environmental awareness and good intentions.

Bounties. This measure would provide a monetary reward either to individuals collecting abandoned automobiles or to automobile wreckers and scrap dealers for all automobiles processed. This differs from a deposit in that no responsibility for proper disposals is placed on the abandoner or individual car owner.

Bounties could be effective in cleaning up the backlog and preventing future abandonments if the bounty were set high enough to cover collection costs. However, it would also subsidize the 80-percent of retired vehicles that now go into the scrap cycle. This disadvantage could be avoided if the bounties were limited to uncollected abandoned automobiles. However, this would require an administrative network to determine the exact status of an automobile and would increase the costs of the program.

The total national costs for 1970 would range from $30 to $60 million if it were assumed that all retirements would become eligible for a $5 to $10 bounty. If bounties could be limited to abandoned automobiles, total annual costs would be around 10 to 15 percent of this amount. In addition, there would be administrative costs that have not been estimated. For example, the institution of a bounty system would require an improved vehicle certification system to prevent multiple bounties for a single vehicle and to avoid paying bounties on stolen vehicles.

Most of the innovative measures discussed above have not received wide-scale trial and application. Although most States have laws prohibiting abandonment, they do not have aggressive statewide programs to prevent abandonment or to collect abandoned vehicles. A study completed in 1971 for EPA determined that 41 percent of the 28 States surveyed had no statewide abandoned automobile program, or responsibility had been delegated to county or local governments. Only six of these States had data on removals.

Existing Programs To Deal with Abandoned Automobiles. Several cities and States have recently initiated more comprehensive programs. Examples of some of these programs are described in this subsection.

California. California has recently instituted a statewide program under the direction of the State Highway Patrol. Estimates of the number of abandoned automobiles run around 200,000. The program basically consists of funding by the State of up to $15 per car for the identifying and clearing of the title of automobile hulks by the cities. The cities then contract with processors/wreckers for removal of the hulks. Funds for the program were raised by a one-time $1 per auto registration fee that generated $15 million. Of the more than 500 counties and cities incorporated in California, more than half have reached an agreement with the State to participate in the program. Several test counties and cities are being closely monitored by the State to both validate the estimate of hulks present and to gather data on the cost and effectiveness of the program.

Maryland. An $8 bounty is provided to both automobile wreckers and scrap dealers for each car processed through their yards. The objective is to provide an incentive for these processors to accept vehicles and prevent inventory accumulations. The vehicle must have been registered in Maryland and proof submitted that it has been processed. Funds for the program are derived from vehicle title transactions ($1 per car). In addition, a tax of $5 per vehicle is levied on automobile wreckers for each vehicle over 8 years old held in inventory over 18 months.

Vermont. Transportation subsidies are provided to communities for the removal of abandoned automobiles. Communities must collect a minimum of 200 vehicles at a central site at their own expense. The State pays independent collectors to crush and transport the automobiles to a scrap processor.

New York City. In New York City the sanitation department contracts with automobile wreckers for the right to collect abandoned vehicles. Wreckers are required to remove a vehicle within 48 hours of notification by the city. Wreckers have to store vehicles for 5 days while an owner search is undertaken. In 1971, 80,000 abandoned vehicles were disposed of in this manner. Contracts with automobile wreckers vary from borough to borough and range from a cost to the city of $9.75 per car in Manhattan to an income to the city of $5.00 in Staten Island. The cost to inspect the car and obtain release for disposal is borne by the police department and runs about $10 per car.

Conclusions

There are only very rough estimates of the annual automobile abandonment rate (700,000 to 1 million vehicles per year in 1972), the abandoned automobile inventory (3.2 million vehicles in 1972), and the accumulation of vehicles in automobile wrecker yards (10 million vehicles in 1972). In addition, there are not sufficient data available to establish the growth rates in these figures. Therefore, it is very difficult to decide upon the scope and extent of a national program in this area at this time.

There are several strategies that could be employed to prevent or reduce abandonment, including disposal certification, deposits, bounties, and provision of storage or disposal sites. Many of these measures have not yet been tested.

The continuance of automobile recycling depends upon maintaining a high price for automobile scrap. There are several developments that might markedly affect this price, including changes in automobile designs, shifts in the steel industry, and changes in export markets. These developments need to be monitored and their potential impacts on automobile scrap recycling need to be evaluated.

PACKAGING

Packaging is the largest and one of the fastest growing product classes in municipal solid waste. Because of its predominance in the waste stream, it has become the focus of a great deal of public attention in recent years. This section outlines the resource consumption and waste generation aspects of packaging activity and provides preliminary data on the technical approaches being explored to control packaging waste.

Resource Consumption and Waste Generation

Packaging activity in the United States has been growing at a rapid rate over the past decade. Shipments of containers and packaging were valued at $19.7 billion in 1971, an increase of 5 percent since 1970, and an increase of 82 percent since 1960.[9] Table 45 shows that in 1958 packaging material consumption equaled 412 pounds per capita. By 1971 per capita consumption had risen to 591 pounds, a growth rate of 43 percent per capita.

The growth of packaging consumption has led to increased consumption of raw materials and energy (with attendant adverse environmental effects) and an increased rate of generation of solid waste. Table 46 shows that packaging accounts for approximately 47 percent of all paper production, 14 percent of aluminum production, 75 percent of glass production, more than 8 percent of steel production, and approximately 29 percent of plastic production. Total packaging material energy consumption represented an estimated 5 percent of U.S. industrial

TABLE 45

CONSUMPTION OF PACKAGING MATERIAL*

Type of material	Total consumption			Per capita consumption		
	Weight (10^3 tons)		Change, 1958-71 (percent)	Weight (lb)		Change, 1958-71 (percent)
	1958[†]	1971		1958[†]	1971	
Paper	16,552	[‡]27,700	67.3	193.0	[‡]271.3	40.6
Glass	5,933	[§]11,100	87.1	69.2	[§]108.7	57.1
Steel	6,198	[¶]7,255	17.1	72.3	[¶]71.1	-1.7
Plastic	368	[§]2,900	688.0	4.3	[§]28.4	793.0
Aluminum	97	[§]757	680.4	1.1	[§]7.4	572.7
Wood and miscellaneous	6,212	[§]10,613	84.2	72.4	[§]103.9	43.5
Total	35,360	60,325	70.6	412.4	590.8	43.3

*Paper figures represent paper packaging produced rather than paper packaging consumed. Other material categories reflect consumption of packaging material.

[†] Darnay, A., and W. E. Franklin. The role of packaging in solid waste management, 1966 to 1976. Public Health Service Publication No. 1855. Washington, U.S. Government Printing Office, 1969. 205 p.

[‡] The statistics of paper. Washington, American Paper Institute, 1972.

[§] U.S. Department of Commerce. *Containers and Packaging.* v.24-25. Washington, U.S. Government Printing Office, [1971-1972]. (Published quarterly.)

[¶] Shipments of steel products. Washington, American Iron and Steel Institute, 1972.

TABLE 46
PACKAGING MATERIAL CONSUMPTION IN RELATION TO TOTAL MATERIAL CONSUMPTION, 1971

Type of material	Consumption		Packaging as a percent of total consumption
	Packaging (10^3 tons)	Total (10^3 tons)	
Paper*	27,700	58,652	47.2
Glass	11,100	14,900	74.5
Steel†	7,255	87,038	8.3
Plastic‡	2,900	10,000	29.0
Aluminum§,¶	757	5,074	14.1

*The statistics of paper. Washington, American Paper Institute, 1972.

†Shipments of steel products. Washington, American Iron and Steel Institute, 1972.

‡[Arthur D. Little, Inc.] Incentives for recycling and reuse of plastics; a summary report. [Cincinnati], U.S. Environmental Protection Agency, 1973. 18 p.

§U.S. Bureau of Mines. Minerals yearbook, aluminum chapter reprint. Washington, U.S. Department of the Interior, 1973.

¶Aluminum statistical review, 1971. New York, Aluminum Association, 1972.

energy consumption in 1971.[10] Table 47 illustrates the energy associated with the production of raw materials for packaging.

Post-consumer solid waste resulting from the discard of packaging material was estimated at between 40 and 50 million tons in 1971. Packaging was thus estimated to be between 30 and 40 percent of municipal solid waste, based on the EPA estimate of 125 million tons of municipal solid waste in 1971.

TABLE 47
ENERGY CONSUMPTION* ASSOCIATED WITH PRODUCTION OF RAW MATERIALS FOR PACKAGING, 1971†

Type of material	Material consumption (10^3 tons)	Energy consumption (10^3 Btu/ton)	Total energy consumption (10^9 Btu)
Paper	27,700	40,800	1,130,000
Glass	11,100	15,256	169,342
Steel	7,255	29,590	214,675
Plastic	2,900	37,088	107,557
Aluminum	757	196,632	148,850
Total	49,712	319,366	1,770,424

*Energy consumption figures include total electrical energy fuel input as well as final material production energy.

†Source: Gordian Associates. Energy consumption for six basic materials industries. U.S. Environmental Protection Agency Contract No. 68-01-1105, 1973. (Unpublished data.)

Trends Toward Increased Use of Packaging

The major functional purpose of all packaging is to protect and preserve the item that is being packaged. In recent years, however, there has been a trend toward increased use of consumer packaging for purposes other than containment or protection. The high cost of labor, for example, has provided an incentive for self-service merchandising, which has resulted in the packaging of products so that they may be displayed, selected, and purchased in an efficient, labor-saving manner. In addition, packaging users have become increasingly aware of the marketing value of packaging. This has resulted in the use of more elaborately designed packaging to attract the consumer to a particular product. Also, packaging manufacturers and users have sought to satisfy the convenience orientation of many consumers. This has led to a proliferation of package sizes for many products.

Tables 48 to 52 illustrate recent growth trends in consumer packaging by material type and end use. Contrasting these data with the overall packaging consumption data presented in Table 45, it is apparent that various categories of consumer products have experienced far greater packaging growth than packaging as a whole. All glass packaging, for example, increased by 57 percent per capita between 1958 and 1971, while beer packaging in glass increased by 290 percent per capita between 1958 and 1970. Aluminum packaging grew 573 percent per capita between 1958 and 1971, while aluminum consumer packaging grew 950 percent per capita between 1958 and 1970. These data are particularly meaningful in light of current trends toward the use of lighter packaging materials (i.e., the substitution of aluminum and plastic for steel and glass, as well as usage of thinner gauges of steel, glass, and aluminum).

Another factor of interest is the growth in product consumption relative to the growth in packaging consumption for that particular product. Overall, the consumption of food in the United States increased by 2.3 percent by weight on a per capita basis between 1963 and 1971.[11] During the same period, however, the tonnage of food packaging increased by an estimated 33.3 percent per capita, while the

TABLE 48
PAPER PACKAGING FOR CONSUMER PRODUCTS*

Type of product	Total consumption			Per capita consumption		
	Weight (10^3 tons)		Change, 1958-70 (percent)	Weight (lb)		Change, 1958-70 (percent)
	1958	1970		1958	1970	
Food:						
Dairy	770.9	1,026.3	33.1	9.0	10.2	13.3
Fresh and cured meat	865.6	1,415.0	63.5	10.1	13.9	37.6
Prepared beverages	108.7	137.4	26.4	1.3	1.4	7.7
Frozen foods	129.8	359.3	176.8	1.5	3.5	133.3
All other	2,022.0	2,994.8	48.1	23.6	29.3	24.2
Subtotal	3,897.0	5,932.8	52.2	45.5	58.3	28.1
Household supplies:						
Cleaning supplies	452.1	547.1	21.0	5.3	5.4	1.9
All other	168.4	148.9	11.6	2.0	1.5	-25.0
Subtotal	620.5	696.0	12.2	7.3	6.9	-5.5
Health and beauty aids	375.2	399.7	6.5	4.4	3.9	-11.3
Other general merchandise	1,727.5	2,342.3	35.6	20.1	22.9	13.9
Total	6,620.2	9,370.8	41.5	77.3	92.0	19.0

*Source: Research Triangle Institute. A study to evaluate the effectiveness and impact of a tax or regulatory mechanism directed toward reducing the quantity of packaging entering the solid waste stream. U.S. Environmental Protection Agency Contract No. 68-01-0791, [1973]. (Ongoing study.)

TABLE 49
GLASS PACKAGING FOR CONSUMER PRODUCTS*

Type of product	Total consumption			Per capita consumption		
	Weight (10^3 tons)		Change, 1958-70 (percent)	Weight (lb)		Change, 1958-70 (percent)
	1958	1970		1958	1970	
Food:						
Beer	410.1	1,912.5	366.3	4.8	18.7	289.6
Soft drinks	359.3	2,511.3	598.9	4.2	24.6	485.7
Prepared beverages	678.6	841.9	24.1	7.9	8.3	5.1
All other	1,988.7	2,950.4	48.4	23.2	28.9	24.6
Subtotal	3,436.7	8,216.1	139.1	40.1	80.5	100.7
Household supplies	108.9	40.3	-63.0	1.3	.4	-69.2
Health and beauty aids	1,219.3	1,244.7	2.1	14.2	12.2	-14.1
Other general merchandise	304.8	105.2	-65.5	3.6	1.0	-72.2
Total	5,069.7	9,606.3	89.5	59.2	94.1	59.0

*Source: Research Triangle Institute. A study to evaluate the effectiveness and impact of a tax or regulatory mechanism directed toward reducing the quantity of packaging entering the solid waste stream. U.S. Environmental Protection Agency Contract No. 68-01-0791, [1973]. (Ongoing study.)

number of food packages increased by an estimated 38.8 percent per capita.[12,13] Several specific examples may be of value here. Between 1958 and 1970, milk consumption decreased by 23.1 percent by weight on a per capita basis.[14] Milk container consumption, on the other hand, increased by 26.1

TABLE 50

STEEL PACKAGING FOR CONSUMER PRODUCTS*

Type of product	Total consumption			Per capita consumption		
	Weight (10^3 tons)		Change, 1958-70 (percent)	Weight (lb)		Change, 1958-70 (percent)
	1958	1970		1958	1970	
Food:						
Beer	896.6	945.7	5.5	10.5	9.3	-11.4
Soft drinks	61.6	706.4	1,046.8	.7	6.9	885.7
Pet foods	159.8	245.9	47.6	1.9	2.4	26.3
All other	2,653.4	2,389.8	-9.9	30.9	23.4	-24.3
Subtotal	3,771.4	4,287.8	13.7	44.0	42.0	-.04
Household supplies:						
Cleaning supplies	3.8	32.0	742.1	.04	.3	650.0
Pesticides	4.7	10.9	131.9	.05	.1	100.0
All other	9.0	36.3	303.3	.10	.4	300.0
Subtotal	17.5	79.2	352.6	.19	.8	321.1
Health and beauty aids	43.0	172.1	300.2	.5	1.7	240.0
Other general merchandise	810.2	612.8	-24.4	9.5	6.0	-36.8
Total	4,642.1	5,151.9	11.0	54.2	50.5	-6.8

*Source: Research Triangle Institute. A study to evaluate the effectiveness and impact of a tax or regulatory mechanism directed toward reducing the quantity of packaging entering the solid waste stream. U.S. Environmental Protection Agency Contract No. 68-01-0791, [1973]. (Ongoing study.)

TABLE 51

PLASTIC PACKAGING FOR CONSUMER PRODUCTS*

Type of product	Total consumption			Per capita consumption		
	Weight (10^3 tons)		Change, 1958-70 (percent)	Weight (lb)		Change, 1958-70 (percent)
	1958	1970		1958	1970	
Food:						
Baked goods	64.2	100.6	56.7	0.8	1.0	25.0
Produce	37.3	96.1	157.6	.4	.9	125.0
Candy and chewing gum	33.5	63.9	90.7	.4	.6	50.0
All other	110.0	387.0	251.8	1.3	3.8	192.3
Subtotal	245.0	647.6	164.3	2.9	6.3	117.2
Household supplies:						
Cleaning supplies	2.3	76.2	3,213.0	.020	.7	3,400.0
All other	.5	23.8	4,660.0	.006	.2	3,233.3
Subtotal	2.8	100.0	7,873.0	.026	.9	6,633.3
Health and beauty aids	6.4	78.7	1,129.7	.07	.7	900.0
Other general merchandise	83.3	633.3	660.3	1.0	6.2	520.0
Total	337.5	1,459.6	332.5	4.0	14.1	252.5

*Source: Research Triangle Institute. A study to evaluate the effectiveness and impact of a tax or regulatory mechanism directed toward reducing the quantity of packaging entering the solid waste stream. U.S. Environmental Protection Agency Contract No. 68-01-0791, [1973]. (Ongoing study.)

TABLE 52

ALUMINUM PACKAGING FOR CONSUMER PRODUCTS*

Type of product	Total consumption			Per capita consumption		
	Weight (10^3 tons)		Change, 1958-70 (percent)	Weight (lb)		Change, 1958-70 (percent)
	1958	1970		1958	1970	
Food:						
Frozen food	16.3	52.8	223.9	0.2	0.5	150.0
Soft drinks	–	151.9	–	–	1.5	–
Beer	–	273.5	--	–	2.7	–
Baked goods	12.3	34.3	178.9	.1	.3	200.0
All other	24.2	300.3	1,140.9	.3	2.9	866.7
Subtotal	52.8	812.8	1,438.8	.6	7.9	1,216.7
Household supplies and health and beauty aids	10.1	20.2	100.0	.1	.2	100.0
Other general merchandise	12.4	31.8	156.5	.1	.3	200.0
Total	75.3	864.8	1,048.4	.8	8.4	950.0

*Source: Research Triangle Institute. A study to evaluate the effectiveness and impact of a tax or regulatory mechanism directed toward reducing the quantity of packaging entering the solid waste stream. U.S. Environmental Protection Agency Contract No. 68-01-0791, [1973]. (Ongoing study.)

TABLE 53

PRODUCT CONSUMPTION IN RELATION TO PACKAGING CONSUMPTION*

Type of product	Consumption (pounds per capita)		Change, 1958-70 (percent)
	1958	1970	
Dairy:			
Product consumption	398.0	354.0	-11.1
Package consumption	10.6	13.3	25.5
Cereals, flour, and related products:			
Product consumption	150.0	140.0	-6.0
Package consumption	.8	.9	12.5
Produce:			
Product consumption	90.2	80.0	-11.3
Package consumption	5.3	7.3	37.7

*Source: Food, consumption, prices, expenditures; supplement for 1971. Supplement to Agricultural Economic Report No. 138. Washington, Economic Research Service, U.S. Department of Agriculture, Aug. 1972.

percent on a unit per capita basis for the same period.[15] Other cases may also be cited. The consumption of vegetables in cans increased by 17.8 percent by weight between 1958 and 1970, while the consumption of cans for vegetables increased by 31.5 percent on a tonnage basis for the same period.[16] Table 53 provides more data on package consumption changes in relation to product consumption changes. In all of these cases, packaging consumption has far outstripped product consumption.

There are three technical approaches that have been considered to reduce material and resource utilization and reduce the waste generation resulting from packaging consumption: using larger containers, eliminating excess packaging of particular products, and using reusable containers. The remainder of this section provides a discussion of these approaches.

Increasing Average Package Size

The trend toward increased use of convenience-sized containers has been one of the contributing factors to increased consumption of packaging materials. Utilization of a greater quantity of smaller containers to fulfill consumption needs results in increased resource use and waste generation. It has been estimated, for example, that elimination of all tomato juice cans smaller than 32 ounces in 1971 would have resulted in a reduction in steel use of 19.6 percent for this product. This example illustrates how use of larger sizes would have significant resource consumption and solid waste generation implications. Reduction of the convenience-sized container could also, however, be attended by impacts on the consumer, the package manufacturer, and the product manufacturer.

With respect to the consumer, it is anticipated that whereas the cost per unit of product will decline under a system of larger sized containers, there would be a significant reduction in consumer choice and convenience (the consumer will not have the choice of different-sized packages to meet his individual needs).

Industry impacts could be significant. Material suppliers would be negatively affected as the demand for packaging material would decrease. Package fabricators would also be adversely affected as the number of containers produced would decline. If product consumption decreased as a result of a shift in container size, product manufacturers would be adversely affected. The warehousing and trucking sectors of the product industries would also experience some disruption if changes in sizes and product mixes necessitated changes in storage and delivery systems.

Eliminating Overpackaging

As packages have come to fulfill more and more functions beyond product containment and protection, their complexity has increased. This complexity has surfaced mainly in multilayer and multimaterial packaging. Thus many single products are now sold in two packages, one which may be necessary for containing the product and one which is utilized to distinguish and advertise the product. Many premium wines, for example, are now sold in bottles that have been placed in sculptured cartons for shelf appeal.[17] Many toiletry containers have also been packaged in highly elaborate cartons for marketing purposes.

Increases in packaging layers have been accompanied by increases in the use of multimaterial packaging. While packaging manufacturers have always combined dissimilar materials, the number of materials suitable for combination has increased dramatically with the advent of plastic packaging. Thus steel and glass, which had traditionally been combined with paper, have now also been combined with plastic.

Although the particular dimensions of the overpackaging issue are difficult to quantify in particular solid waste generation terms, it appears that overpackaging will be increasing at an extremely rapid rate as marketing takes a firm place beside protection and containment as key motives for packaging consumer products.[18]

Reusing Packaging

Approximately 90 percent by weight of all packaging is discarded by the consumer within 1 year of purchase.[19] Most packages are designed for short lifetimes, with little attention given to the possibilities for reusing the package. There are, however, positive environmental effects resulting from the reuse of various container types. These effects include a decrease in the environmental discharges associated with production of the packaging (e.g., air pollution and water pollution), a reduction in material and energy consumption, and a decrease in the quantities of solid waste generated.

Two examples may be cited here to illustrate the potential environmental effects. In the first, the use of 1,000 tons of single-use corrugated containers is compared to the use of reusable corrugated containers designed to ship an equivalent volume of product. Each of the reusable containers is assumed to be used five times. Table 54 provides the data for the detailed conparison. These data reveal that the reusable container system utilizes approximately 80 percent less energy than is used by the single-use container system, that air pollution decreases by 57 percent under the reusable system, that water pollution decreases by approximately 98 percent, and that solid waste savings of almost 77 percent accrue in the use of reusable corrugated containers. In the second example, a refillable bottle system is compared with four different single-use beverage container systems. Table 55 provides the data for the detailed comparison. The refillable system, for example, provides resource consumption savings, energy consumption savings, and air and water pollution reduction.

Although the environmental effects that can be derived from reusable packaging systems are positive, there are technological and economic issues that are likely to affect the establishment and implementation of these systems. A brief discussion of the major barriers follows.

The Development of Reusable Packages. At the present time, there are relatively few package types designed for reuse. In the consumer product sector, the refillable bottle and the reusable carton are the only systems in use. In the industrial sector some drums, pallets, and boxes are designed for reuse.

TABLE 54

COMPARISON OF THE USE OF 1,000 TONS OF SINGLE-USE CORRUGATED CONTAINERS WITH THE USE OF REUSABLE CORRUGATED CONTAINERS PROVIDING THE SAME DEGREE OF SERVICE*

Environmental impact	Single-use container system	Reusable container system†	Difference (percent)
Production energy consumption (10^6 Btu)	25,554.0	5,017.0	-80.3
Production air pollution generation (lb)	38,183.7	11,403.9	57.0
Production water pollution generation (lb)	849,976.0	18,998.0	-97.8
Post-consumer solid waste generation (tons)	1,000.0	‡231.0	-76.9

*Source: Gordian Associates. Energy consumption for six basic materials industries. U.S. Environmental Protection Agency Contract No. 68-01-1105, Task No. 68-01-1111, 1973. (Unpublished data.)

†Assumes that each reusable container is utilized five times prior to discard.

‡To allow for reuse five times, each container has been designed to utilize 25 percent more linerboard than the single-use container.

TABLE 55

COMPARISON OF FIVE DIFFERENT CONTAINERS* FOR DELIVERING 1,000 GALLONS OF BEVERAGE†

Environmental impact	10-trip returnable glass‡	All steel§	Bimetallic§	One-way glass‡	Aluminum§
Energy (10^6 Btu)	24	41	57	72	91
Virgin raw materials (lb)	1,538	2,029	1,677	7,515	578
Water volume (10^3 gal)	11	38	34	37	16
Waterborne waste (lb)	45	349	335	68	249
Atmospheric emissions (lb)	111	157	234	328	381
Post-consumer solid waste (ft^3)	12	4	3	41	3
Industrial solid waste (lb)	8	71	61	32	29

*All containers are 12-ounce beer.

†Source: Preliminary data prepared by the Midwest Research Institute for U.S. Environmental Protection Agency Contract No. 68-01-1848.

‡Capped with steel closures; solid bleached sulfate paperboard carriers are included.

§Plastic ring-type carriers are included.

The institution of a large number of reusable packaging systems would therefore require some product design and development activity.

Systems for Returning Reused Containers. If a package is to be reusable, it must be obtained from the ultimate user and returned to the point at which the container can be refilled. For consumer packaging, this might involve establishing either a deposit system that would provide an incentive for the consumer to return the container to a particular location where it could be obtained by the filler (as with the refillable soft drink bottle) or a system in which containers would be separated by the household and collected for return to the filler.

With respect to commercial or shipping packaging, a system similar to those currently in operation might be employed. At the present time, for example, the distributors of commercial packaging to large outlets often return to collect the used packages for reuse. This type of system could be employed on a large scale if reusable packaging became more widespread. For either commercial or consumer packaging users, then, it is clear that systems for obtaining and returning the used containers would have to be developed and instituted prior to the widespread acceptance and use of refillable containers.

Economic Impacts. Substantial economic effects are likely to result from the institution of reusable packaging systems. These impacts will affect all major industries from material suppliers to retailers and might include production and sales volume changes, employment dislocations, capital investment requirements, and obsolescence of existing equipment. The extent of economic dislocation is expected to be dependent upon the mechanism used to either create incentives or require the utilization of reusable containers. The beverage container section of this report provides considerable detail on the economic impacts that might occur from a shift to a refillable beverage container system.

Packaging Control Measures

Both fiscal and regulatory measures could be used to implement the approaches described to reduce material and resource utilization and reduce the waste generation resulting from packaging consumption. Fiscal measures could be used to provide incentives for decreasing packaging material consumption, encouraging the reuse of packaging, or encouraging the use of recycled material in packaging. Regulatory mechanism could set standards that require consumption decreases, reuse, or the use of recycled materials in packaging.

An EPA study is currently underway to assess the effectiveness and impact of four mechanisms designed to decrease the generation and increase the recycling of packaging waste: a tax on package weight, a packaging weight tax with a rebate for recycled material use, a packaging unit tax for rigid containers, and required utilization of recycled material in packaging.

Although this study is not yet complete, some tentative findings can be presented at this time. A tax on the weight of packaging is likely to have some source reduction effects because of absolute decreases in material consumption at the manufacturer level and shifts in material use for certain products. The total waste weight reduction for a tax of $20 per ton of packaging used is not expected to exceed 4 million tons.[20] Energy use reductions could be expected on the order of 1 to 2 percent of current energy use in packaging production. A unit tax on rigid containers is likely to have a slightly greater source reduction effect. Reductions of packaging waste of 4 to 5 million tons are anticipated from a $0.01 per unit tax.[20]

Both of these broad-based fiscal measures are likely to discriminate against certain packages and may even result in shifts to materials and packages that are less desirable from an environmental point of view. For example, a tax on packaging weight would discriminate against refillable glass bottles and favor aluminum beverage cans. With a unit tax, all containers would be taxed equally regardless of their material content or weight.

An alternative to fiscal incentives for packaging reduction is a comprehensive regulatory program for all products. Such an approach would be extremely difficult and cumbersome to administer given the wide variety of packaging end uses and configurations.

Studies of the tradeoffs between fiscal and regulatory approaches to packaging control have not been completed. Furthermore, it is necessary to evaluate the environmental benefits and the costs of these measures before we can confidently provide specific views on packaging waste reduction.

BEVERAGE CONTAINERS

A great deal of public attention has been focused on the impact of beer and soft drink containers on the environment. This concern has centered on the aesthetic problems associated with beverage container litter, solid waste generation factors, and the overall environmental impacts associated with beverage container production and use. While these latter aspects apply to all packaging and, in fact, to all consumer goods, the litter issue renders beverage containers somewhat unique. For this reason, beverage containers have become a highly sensitive public issue and will be discussed separately in this report.

Trends Toward Increased Use of Nonrefillables

Consumption of beer and soft drink containers has grown and continues to grow faster than population growth and the consumption of beverages themselves. Table 56 illustrates that per capita beverage container consumption rose from 87 units in 1959 to 230 units in 1969, an increase of 164 percent. In the same period, the per capita consumption of beer and soft drinks rose 29 percent. In the 1959-69 period, the use of refillable bottles decreased as the average number of fillings per container declined from 3.7 to 1.8. In large part as a consequence of this decline, the total number of beverage containers consumed rose from 15.4 billion units in 1959 to 46.8 billion units in 1969.

TABLE 56

BEVERAGE CONTAINER CONSUMPTION*

Item	1959	1969	Growth rate (percent)
Containers consumed (billions)	15.4	46.8	204
Beverage fillings consumed (billions)	58.4	85.8	47
Average number of fillings per container	3.7	1.8	–
Container consumption per capita	87	230	164
Beverage fillings consumed per capita	325	420	29

*Source: Bingham, T. H., and P. F. Mulligan [Research Triangle Institute]. The beverage container problem; analysis and recommendations. Washington, U.S. Government Printing Office, 1972.

Beverage Containers and the Environment

Litter. Beer and soft drink containers form a large and highly visible segment of roadside litter. It has been estimated, for example, that at least 2.2 billion beverage containers became litter in 1969, from 20 to 32 percent of all roadside litter by item count.[21] Of these containers, it is estimated that 71.3 percent were beer containers, 25.7 percent were soft drink containers, and approximately 3.0 percent were wine and liquor bottles.[21] By type of container, it is estimated that 73.1 percent were cans, 17.0 percent were nonrefillable bottles, and 9.9 percent were refillable bottles.[21]

A survey by the Oregon State Highway Division indicates that by volume, beverage cans and bottles form approximately 62 percent of the litter along the State's highways, bottles accounting for 22 percent and cans, 40 percent.[22] Although this is but one survey, it indicates that beverage containers might represent a greater visual blight than item counts would seem to indicate. This is further borne out by a somewhat limited four-city survey that revealed that the public thinks beverage containers constitute nearly 40 percent of all litter.[23]

Resource Use and Solid Waste. In 1972, approximately 8.8 million tons of beer and soft drink containers (6.2 million tons of glass, 2 million tons of steel, and 0.6 million tons of aluminum) were consumed in the United States. This represents approximately 20 percent of all packaging waste and 7 percent of total municipal solid waste.

Environmental Impact. With respect to the environmental impacts resulting from beverage container production, data are presented in Table 55 on the impacts associated with the production of five container types. These data reveal that, for the delivery of equivalent volumes of beverage, a refillable bottle (assuming usage of each bottle 10 times), as compared to any other type of beverage container considered, provides a reduction in energy consumption from 41 to 74 percent, a 34- to 87-percent reduction in waterborne waste, and a reduction in air effluents from 30 to 71 percent.

Control Measures

There are three major types of strategies that have been proposed for reversing the trend toward nonrefillable containers and curbing the beverage container portions of litter and solid waste: mandatory deposit systems for all beverage containers, bans on the production and sale of nonrefillable containers, and low taxes on beverage containers to be used for increased litter cleanup. Each of these strategies is to generate revenues analyzed in this subsection, and Table 57 summarizes the results of the analysis.

Mandatory Deposit. The mandatory deposit alternative selected for analysis would require the retailer to pay $0.05 for every empty container of beer and carbonated soft drinks. The retailer would be required to accept from the consumer any empty container of the kind, size, and brand sold by that retail outlet. Retailers, in turn, could return empty containers to the distributor who would also be required to pay the $0.05 refund.

Mandatory deposit legislation has been passed at both the local and State level. (Oregon and Vermont; Oberlin, Ohio; Bowie, Maryland; and Ann Arbor, Michigan, have enacted mandatory deposit legislation.) In these cases, the costs and benefits of the approach would have to be analyzed on an individual basis because of varying degrees of littering, industry intensity, and consumption. The projected costs and benefits of implementation of this strategy at the national level follow.

Litter Reduction. It is estimated that implementation of a $0.05 mandatory deposit is likely to result

TABLE 57

PROJECTED BENEFITS AND COSTS OF CONTROL MEASURES

Impact	Mandatory deposit	Ban	Tax
Benefits:			
Litter reduction	Substantial improvement	Substantial improvement	Substantial improvement
Solid waste reduction	Some improvement	Some improvement	No change
Environmental impact reduction	Substantial improvement	Substantial improvement	No change
Costs:			
Sales volume change	Possible slight decrease	Likely decrease	No decrease
Industry dislocation	Dislocation, but less than with a ban	Substantial dislocation	No dislocation
Employment impact	Dislocation, but no net loss	Dislocation, and likely net loss	No dislocation
Tax revenue loss	Likely decrease	Likely decrease	No decrease
Beverage price	Lower on average	Lower on average	Higher on average
Consumer choice impact	Some limitation	Choice limited	No change
Consumer convenience impact	Higher price for convenience	Higher price for convenience	No change

in a reduction in the beverage container portion of the litter. This would result partly from decreased littering and partly from increased scavenging. One estimate of the quantities of beverage container litter to be reduced is 60 percent.[23] Preliminary data from the State of Oregon indicate a reduction of beverage container litter of from 70 to 75 percent.

Solid Waste Reduction. Beverage container consumption in 1972 equaled 8.8 million tons.[24] If a $0.05 mandatory deposit system resulted in the use of only refillable beverage containers (each container to be used 15 times), solid waste reductions of approximately 6 million tons would occur.

Environmental Impact. Any measure that resulted in increased usage of the refillable glass container would also result in significantly decreased environmental impact. A mandatory deposit system resulting in a predominately refillable bottle market (85 to 90 percent refillables), as compared to the current market mix of containers, would result in (1) a material use reduction, (2) energy savings, (3) an air pollution reduction, (4) a water pollution reduction, (5) reduced mine waste production.

Sales Volume Change. Sales of beverages may decline slightly under a mandatory deposit system. A sales decline could result from a decreased number of sales outlets (e.g., vending machines may decrease in number) or from a switch to other beverages without the required deposit (e.g., juice or wine). This decline has been estimated at from 4 to 8 percent.[23] Preliminary experience in Oregon, as will be discussed later in this section, reveals no decline in sales. Current growth rate in the industry is estimated at 6 percent a year.[24] Thus, the effect could range from no change in growth to 1 year of no growth and subsequent years at present growth.

Industry Dislocation. A $0.05 mandatory deposit that resulted in a switch to refillable bottles would eliminate a substantial portion of metal beverage cans and would have significant impacts on that industry (e.g., a reduction of 75 percent in the use of beverage cans would be equivalent to a decline of $1.1 billion worth of shipments in 1971).[25] Approximately 2 percent of steel production is currently related to can manufacture, and this steel use could be totally eliminated. In the aluminum sector, beverage containers represent 11 percent of aluminum shipments, which would be significantly affected. Major disruptions could also occur within the brewing industry, particularly for the national shipping brewers, if a switch was made from current beer distribution methods.

Employment Impact. A mandatory deposit could result in large reductions in employment in the container industries (estimated at 60,500 jobs, mostly in skilled categories) and large additions to employment in the beverage and distribution industries (estimated at 60,800, mostly unskilled categories).[26] The net effect could be a small increase in jobs and probable drop in labor income, accompanied by substantial disruptions in the affected industries.

Tax Revenue Loss. Tax revenues would decline substantially during a period of transition because of employment wage decrease and tax writeoffs. An estimate of the quantity of tax revenue loss is $803 million for the first year (based on the total elimination of beverage can production and an 8-percent beverage sales decline).[27] This figure would be decreased if beverage sales did not decline substantially and if beverage cans continued to be sold.

Beverage Price. The average price paid by all consumers for beer and soft drinks should decrease slightly because the higher priced nonrefillable containers would only be sold in small quantities. Increased handling costs (estimated at $0.015 per container at retail) and costs related to equipment changes in the brewing and soft drink industries would likely be passed on to the consumer, however.[28] These costs could result in a rise from the current price of refillable containers. It is estimated that the price per unit of beverage is likely to be on the order of $0.005 per unit lower than the current nonrefillable price.

Consumer Convenience. A mandatory deposit system would raise the price of convenience. If a consumer purchased a container and did not return it for a refund, he would in effect be paying $0.05 extra for not returning it.

Consumer Choice. A ban that prohibited the sale of various types of containers would limit consumer choice. A mandatory deposit does not directly prohibit the sale of any container type. However, it forces the consumer to pay a higher price—equivalent to the deposit—for the convenience of discarding a container.

Ban on Nonrefillable Containers. A ban on nonrefillable containers would act in the same way as a mandatory deposit, as bottlers of beer and soft drinks would probably place deposits on their refillable beverage containers to retrieve them for refilling. A ban on nonrefillables would, therefore, result in benefits similar to those of a mandatory deposit. The costs of a ban would be more severe than those of a deposit, however, because a ban would prohibit utilization of any container other than one that is refillable.

Specifically, a ban would completely eliminate the beverage can manufacturing industry ($1.5 billion in shipments in 1971) as well as the contract canning industry. The uses of steel and aluminum for beverage cans would also be eliminated.

A ban prohibiting the sale of nonrefillables would limit consumer choice because the only containers available would be the refillable bottle. If a consumer discarded rather than returned a refillable container, he would lose the deposit and, in effect, he would be paying extra for this convenience.

Litter Tax. The low litter tax selected for analysis would require that an additional $0.005 per container be paid on the sale of each container for beer or carbonated soft drinks. The tax would be imposed at the point of purchase of the container by the beverage industry. The projected costs and benefits of implementation of this measure at the national level follow. Litter taxes can also be imposed at the State or local level (the State of Washington has enacted a low litter tax). Where implemented at the State or local level, the costs and benefits must be analyzed in relation to the characteristics of the particular area. The specific effects of a litter tax in reducing beverage container litter are difficult to predict accurately. Some qualitative comments follow.

Litter Reduction. While a low litter tax probably would not cause any change in the rate of littering, it would raise revenue to be used for litter collection. In 1972, a $0.005 per container tax would have raised approximately $278 million in revenue. If this amount were applied totally to litter cleanup activities, it would increase the frequency of litter collection by approximately five to six times.[29] However, it is possible that once raised, the revenues might be used to substitute for present funds.

Solid Waste Reduction. A low litter tax would have no effect on beverage container solid waste.

Environmental Impact. A low litter tax would have no effect on the environmental impact of beverage container production and use.

Sales Volume Change. No changes are expected because a tax of $0.005 per container is not likely to affect consumption patterns. Studies of the elasticity of demand for beer and soft drinks indicate that both are relatively inelastic and that a price increase of $0.005 per container would not affect demand substantially.[30]

Industry Dislocation. A low litter tax is not likely to cause dislocation in the beverage or container industries.

Employment Impact. No employment impact would be expected as a result of imposition of a low litter tax.

Tax Revenue Loss. No increase in tax writeoffs would be likely as a result of a low litter tax as the tax is not likely to affect beverage or container consumption.

Beverage Price. A low litter tax would increase the costs of all container types by the amount of the tax. If the charges were passed on to the consumer, the average price of beer and soft drinks would be increased an average of slightly less than $0.005 per filling. The price increase for refillables will be less as the tax can be amortized over several fillings.

Consumer Choice and Convenience. Consumer choice and convenience would be unaffected by a low litter tax.

The Oregon Mandatory Deposit Law

Public interest in beverage containers has led to a large number of legislative proposals to ban, tax, or impose mandatory deposits. A mandatory deposit law in Oregon has been in effect since October 1, 1972, and a similar law in Vermont went into effect September 1, 1973. The State of Washington is currently the only State with a low litter tax in effect. Because Oregon is the only State for which detailed data are available on the impacts of beverage container legislation, the effectiveness and impacts of its law will be discussed in some detail.

Oregon's "Bottle Bill" requires a minimum $0.02 refund to purchasers on the return of "certified" containers of beer, malt beverages, and carbonated soft drinks, and a $0.05 refund on the return of all other beverage containers for those beverages. Certified containers are defined as containers that are used by, and that will be accepted for, reuse by more than one manufacturer. In addition, the law outlaws the sale of the fliptop or pulltab beverage container. A publication of EPA has reported the trends emerging from the experience of the first 6 months after enactment of the law.[31] The remainder of this subsection summarizes the effects of the law through June 1973.

Litter. Beverage containers in litter decreased substantially between winter and spring of 1971-72 (before enactment) and winter and spring of 1972-73 (after enactment). Table 58 illustrates these findings.

Container Usage. Cans for beer and soft drinks have declined to approximately 2 percent of the market share, and nonrefillable glass bottles have been completely eliminated.

Prices and Sales. Sales of beer and soft drinks have not declined since the law went into effect. A price rise of up to 1.7 cents per container did occur in the spring of 1973, although it is not clear as to whether this can be attributed to the bottle bill, inflation, or other cost increases.

Employment. Approximately 142 jobs were lost as a result of the bottle bill, 62 in a canning facility in Oregon, and 80 in a can manufacturing plant outside of the State.

TABLE 58
A COMPARISON OF OREGON LITTER DATA BEFORE AND AFTER INSTITUTION OF THE MANDATORY DEPOSIT ACT*

Type of litter	Winter (October to February)			Spring (March to June)		
	Average number of items per mile per month, 1971-72	Average number of items per mile per month, 1972-73	Decrease (percent)	Average number of items per mile per month, 1972	Average number of items per mile per month, 1973	Decrease (percent)
Beverage containers	269	51	74	103	19	-75
Other litter	456	219	52	187	175	5
Total	728	270	56	290	195	-25
Beverage containers as a percent of total litter	37	19	42	36	10	-65

*Source: EPA analysis of data supplied by the Oregon State Highway Department of Litter Surveys.

The State of Oregon will be conducting a more comprehensive study of the effects of this legislation and is expected to report results by the end of 1974.

Conclusions

Beverage containers form a significant and visible portion of roadside litter and a substantial and increasing percentage of solid waste. This is due in large measure to the growth of the nonrefillable container at the expense of the refillable bottle. There is analytical evidence to indicate that replacement of the existing beverage packaging system with a refillable bottle system would result in substantive decreases in air and water pollution and energy and resource use.

Preliminary data from Oregon indicate that a mandatory deposit system on all beverage containers results in the establishment of a predominantly refillable bottle system and also results in a reduction in litter. These effects are accompanied by some unemployment and by adverse economic impacts on the manufacturers and fillers of nonrefillable containers. More conclusive data on the impacts of the Oregon law are expected in the future.

RUBBER TIRES

Consumption and Discard

In 1971, 266 million tires for passenger cars, trucks, and motorcycles were shipped by domestic tire manufacturers or imported for consumption in the United States (Table 59). In that year, tires taken out of service totaled 240 to 250 million.[32]

Of the tires taken out of service, approximately 46 million were retreaded, 7 million were consumed by the rubber reclaiming industry, and roughly 2 million were consumed by tire splitters.[33] The remaining 185 to 200 million tires, weighing approximately 2.4 million tons, were disposed of by retailers, retreaders, or consumers or were left on discarded vehicles. (See Table 60 for tire disposal statistics for 1969.) The most common disposal method is land disposal, but many tires become litter or are left to accumulate at various locations.

Disposal Issues

Tires are one of the most difficult consumer wastes to dispose of properly. In sanitary landfills, whole tires cannot be effectively compacted and tend to work their way up to the landfill surface. They also consume more landfill space per unit weight than other items and are not biodegradable.

TABLE 59

TIRE SHIPMENTS, 1971

Category of tire	Number of tires (millions)
New replacements (passenger cars, motorcycles, and trucks)	*153.4
Retread replacements:	
Passenger cars	†36.0
Trucks	†10.2
Original equipment (passenger cars, motorcycles, and trucks)	*56.0
Exports (passenger cars, motorcycles, and trucks)	*2.0
Imports:	
Passenger cars and motorcycles, original equipment	‡9.1
Truck and bus tires, original equipment	‡1.5
Total	268.2

*Tire report; statistical highlights, 1971. New York, Rubber Manufacturers Association, Feb. 1972.

†Retreading; N.T.D.R.A. marketing guidelines. Washington, National Tire Dealers and Retreaders Association, Sept. 1972.

‡U.S. Bureau of the Census. U.S. foreign trade. Imports TSUSA commodity by country; annual 1971. Consumption and general quantity and value, country. Report FT 246-71. Washington, U.S. Government Printing Office, 1972. 621 p.

TABLE 60

TIRE DISPOSAL, 1969*

Point from which final disposal is made	Number of tires (millions)
Retailer	78.3
Retreader	64.3
Consumer	4.0
Discarded vehicle	37.3
Total	183.9

*Source: International Research & Technology Corporation. Tire recycling and reuse incentives. U.S. Environmental Protection Agency Contract No. CPE-R-70-0047, 1972.

Tires on the surface of landfills or dumps or littered in urban or rural areas provide nesting places for rodents, flies, and mosquitoes.

Shredding, splitting, or otherwise reducing the size of tires overcomes the problem of landfilling to a large degree. Shredding is the most feasible method of physically altering the tires but is presently employed only in a few locations. Cost is the primary deterrent, and neither public nor private entities are likely to pay the price of processing in the absence of disposal regulations.

A small number of tires can be combined with large quantities of refuse in incineration as long as they do not comprise more than about 5 percent of the charge. Larger percents of tires result in damage to furnace walls and also require flue gas control. Tires represent only about 1.5 percent of the municipal waste stream but are often delivered to a disposal site in large batches rather than in an even day-to-day flow. Shredding of the tires would allow the percent of tires in the incinerator charge to be increased above 5 percent if the shredded rubber is thoroughly mixed with other waste materials.

Recycling Opportunities and Problems

There are three means by which rubber tires are presently recycled: retreading, conversion by rubber reclaimers into new products, and physical conversion by tire splitters into new products.

Retreading. As percents of new tire shipments, retreaded passenger tires have dropped from 25 percent in 1963 to 17 percent in 1968. Truck tire retreads dropped from 32 to 28 percent in the same period.[34]

Tire performance and consumer preference are two critical factors inhibiting the expanded usage of retreads. Poorly constructed retreads do not perform as well as new tires, especially at high speeds. This is primarily because the bond between the carcass and tread can fail, causing the tread to come loose from the tire. This bond could be improved if the precise chemistry and carcass dimensions of every retreaded tire were known. However, tires of various manufactures have slightly different chemistry or size, making the development of a perfect bonding agent and exact tread fitting difficult.

Consumers have a preference for new tires because retreads are felt to be inferior. Manufacturers sell an increasing variety of low-priced new tires, which in essence compete with retreads.

A factor that would ultimately restrict retreading is the technical suitability of old carcasses for retreading. Only about 35 percent of the discarded passenger tires are suitable for retreading. This is largely because consumers allow tires to become too worn before replacing them and because driving on underinflated tires weakens the tire carcass.

Better tread bonding, leading to consistent tire performance, and consumer education and cooperation would be required to increase tire retreading.

Rubber Reclaiming and Tire Splitting. Rubber reclaiming and tire splitting are limited by the market potential for the products they produce. Reclaimed rubber is not technically suitable for making new tires. The total production of other lower grade rubber products produced by reclaimers and tire splitters (e.g., doormats, hoses, and belts) is extremely small relative to tire discards. In 1969 the entire output of these industries was only about 290,000 tons.[35]

New Recycling Opportunities

There is a variety of new potential means of recycling rubber tires; the most promising include chemical decomposition, incineration for steam production, road building, and use as offshore reefs.

Chemical Decomposition. Destructive distillation, carbonization, and hydrogenization are thermal conversion processes that may be used to recover the chemical constituents of tires. The first two processes are both forms of pyrolysis–thermal decomposition in a low oxygen atmosphere; hydrogenization is a process of chemical synthesis involving addition of hydrogen. The primary product of carbonization (high-temperature destructive distillation) is carbon black, a major tire raw material. Lower temperature destructive distillation yields a mixture of oils, gases, and carbon residue with significant fuel value. Hydrogenization yields hydrocarbon products that can be used in tire manufacturing.

Pilot-plant-scale carbon black processes utilizing scrap rubber have been tested by some of the major rubber companies. It was reported that the processes are feasible but economically unattractive at present, with costs of about three to four times that of carbon black production by conventional means from petroleum.[36]

Destructive distillation of tires has been examined by the Bureau of Mines in conjunction with a major rubber company. The products consist primarily of heavy oils, light oils, gases, and char. It has been reported that the value of these products from 100 pounds of tires is approximately $1.50 (i.e., $30 per ton of tires processed). It has been further suggested that even at this value the process is uneconomical if shipping, handling, storage, and preparation costs are included.[37]

Hydrogenization of the products of destructive distillation has been examined by the Hydrocarbon Research Institute at the pilot plant scale, and preliminary projections were made that such a plant could operate at a profit if tires could be obtained for $5 per ton.[38]

Incineration for Steam Generation. Incineration of tires for steam generation in special furnaces has been examined by some of the major tire manufacturers and appears to be a promising disposal and recovery method. One such plant has been built. When in full operation, the plant will handle about 1 million tires per year. The incinerator is reported to be completely odorless and pollution free. The major drawback appears to be the high capital cost of the equipment.

Road Building. Road building and repair offers a large potential outlet for old shredded tires. Rubber that has been ground into small particles can be added to asphalt as a binder. The rubber is reported to enhance the resilience of the road in cool weather and reduce the flowing characteristics in hot weather. Rubber can reduce the tendency of asphalt to bleed to the road surface where it presents a skidding hazard, and the rubber in the mix allows more asphalt to be added for better aging and reduced raveling tendencies.[39] However, estimated costs of adding rubber to asphalt mix (usually in concentrations of 3 to 8 percent) range from $1.50 per ton to $2.50 per ton of mix.[40] The justification for this cost will depend on whether the cost can be offset by lower maintenance costs or longer road life. Tests of rubberized roads to quantify benefits are presently underway in several locations.

The State of New York is already using reclaimed rubber with hot asphalt to seal cracks and joints, and Arizona has laid rubberized asphalt on streets and airport aprons.

Reef Building. Tires have been used to construct artificial reefs for fish spawning on the East and Gulf coasts in response to increasing interest in sportsfishing. It is reported that water action on the West coast is too strong for construction of artificial reefs. EPA does not presently have extensive data on the economics and long-range potential of this method of tire reuse.

Conclusions

Motor vehicle tires are relatively difficult to dispose of by landfill and incineration, and many tires are disposed of inadequately, left as litter, or piled on open ground. The existing markets for recycling and reuse of old tires are the retreading industry, the rubber reclaimers, and the tire splitters. The latter two markets are very small relative to the quantity of tires discarded, and the retreading market has been declining in recent years.

Some research and development of new options for tire recycling has been carried out by both private industry and the Federal Government. Most of these techniques are more costly than disposal (which is often inadequate from an environmental or aesthetic point of view). Research and development, demonstrations, technical assistance, regulations, and fiscal subsidies are all possible mechanisms for instituting tire processing or recovery. These mechanisms need to be evaluated and the technical and economic feasibility of tire recycling needs to be further analyzed before recommendations can be made.

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Appendix A

DESCRIPTION OF NEWLY DEVELOPED RESOURCE RECOVERY SYSTEMS UNDER DEMONSTRATION THROUGH THE EPA GRANT PROGRAM

SHREDDED WASTE AS A COAL SUBSTITUTE–ST. LOUIS, MISSOURI

The city of St. Louis has operational responsibility for the waste processing facilities, and the Union Electric Company has operational responsibility for the fuel firing facilities. The time and cost schedule for design, construction, and operation is given in Table 61.

Incoming residential solid waste is shredded to a 1½-inch particle size. The shredded waste is air classified into two fractions: a "light" combustible waste fraction containing about 80 percent of the incoming waste and a "heavy" waste fraction containing metals, glass, rocks, rubber, and heavy plastics. Ferrous metals are separated from the heavy waste fraction. The product outputs are shown in Table 62.

The light combustible waste fraction is trucked 18 miles to Union Electric Company's Meramec Power Plant. The solid waste fuel is pneumatically fired to an existing 125-megawatt suspension-fired boiler at a rate of 15 percent of the boiler's fuel requirements. The primary boiler fuel is either coal or gas. The boiler is equipped with electrostatic precipitators for particulate emission control.

The plant was designed to process 650 tons of solid waste per day (in a 2-shift operation) and to produce 520 tons of supplemental fuel per day. Raw, untreated solid waste has a heat content value of 4,500 to 5,000 British thermal units per pound. Processing of solid waste to separate the combustible portion can increase the heating value to approximately 6,000 British thermal units per pound. In comparison, coal has a heating value of approximately 10,000 British thermal units per pound. In addition to having a comparable heating value, processed municipal solid waste contains much less sulfur and produces less ash than coal. The most dramatic comparison of solid waste to coal is an economic one. Coal is worth $8 per ton to $15 per ton. Solid waste represents a negative worth of $2.00 per ton to $25.00 per ton (the range of disposal costs). Consequently, processed solid waste competes quite favorably in the energy markets.

It should be noted that about 13 percent by weight of the incoming waste will require landfilling.

TABLE 61

ST. LOUIS, MISSOURI, SYSTEM TIME AND COST SCHEDULE

Activity	Time period	Total cost (dollars)	Federal share of cost (dollars)
Design and construction	July 1970 to April 1972	3,288,544	2,180,026
Operation and evaluation	May 1972 to August 1974	600,000	400,000
Total		*3,888,544	2,580,026

*Union Electric Company is to provide $950,000 and the city of St. Louis is to provide the remaining $358,518 of the non-Federal share.

TABLE 62

ST. LOUIS, MISSOURI, SYSTEM OUTPUT

Product	Quantity (tons*)	Price (dollars/ton)
Solid waste fuel	80	†4.20
Ferrous metal	7	17.00

*Per 100 tons of solid waste input.

†Gross fuel savings to Union Electric Company without recovery of cost.

Boiler exhaust gases will be controlled by an electrostatic precipitator to meet local and Federal standards. Boiler particulate emissions caused by the use of solid waste as supplemental fuel are not expected to be significantly greater than particulate emissions resulting from firing coal alone. However, this conjecture is still unconfirmed pending comprehensive stack testing. No wastewater will be discharged from the solid waste processing facility. At the power plant, boiler bottom ash is sluiced to a settling pond. Because this ash will now contain solid waste ash, the settling pond effluent will be appropriately monitored.

The projected system economics is shown in Table 63.

TABLE 63

ST. LOUIS, MISSOURI, PROJECTED SYSTEM ECONOMICS*

Item	St. Louis	Union Electric Company
Capital investment (dollars)	2,394,000	600,000
Annual costs (dollars):		
Amortization and interest	227,000	120,000
Operation and maintenance	618,000	20,000
Total	845,000	140,000
Cost before revenue	†5.00	‡1.05
Revenues:		
Ferrous metal	†1.00	–
Fuel savings	–	‡4.20
Net cost (saving)	†4.00	‡(3.15)

*Based on a 2-shift operation, with 1971 actual capital costs and 1972 estimated operating and maintenance costs. The assumptions are that 169,000 tons of raw solid waste are throughput per year, and 135,000 tons of solid waste fuel are produced per year.

†Dollars per ton of input waste.

‡Dollars per ton of fuel.

Preliminary data indicate that the project will be successful. Union Electric Company is considering adapting other boilers to burn solid waste as supplementary fuel. Other utilities have shown a significant interest in experimenting with the concept as well.

SHREDDED WASTE AS A FUEL SUBSTITUTE OR AS COMPOST–WILMINGTON, DELAWARE

The State of Delaware has operational responsibility for this material and energy recovery facility.

The plant will be designed to process daily 500 tons of municipal solid waste, 15 tons of industrial waste, and 230 tons of 8 percent solid sewage sludge. The time and cost schedule for design, construction, and operation is given in Table 64.

Incoming municipal solid waste will be shredded to a 6- to 8-inch particle size. The shredded waste will be air classified into two fractions: a "light" combustible waste fraction containing about 60 to 75 percent of the incoming waste and a "heavy" waste fraction containing metals, glass, wood, heavy plastics, textiles, rubber, and rocks.

The light fraction will be shredded again to a 1- to 2-inch particle size. Most of the light fraction will then be sent directly to a power plant for use as supplemental fuel in oil-fired boilers. The remaining light fraction will be mixed in aerobic digesters with partially dewatered sewage sludge for use as supplemental power plant fuel or compost or both, depending upon market conditions.

The heavy fraction will be processed to remove ferrous metals for recycling. The remaining heavy materials will be mixed with selected industrial wastes and pyrolyzed. Heat from the pyrolysis gases will be used to help dewater the sewage sludge. Aluminum and glass will be recovered from the pyrolysis residue. (See Table 65.) The remaining residue will be landfilled (about 10 percent by weight of the incoming waste).

Several utilities have shown a significant interest in implementing the shredded waste as a fuel concept for oil-fired boilers. Boilers that burn oil can be adapted to burn solid waste if the boilers were originally designed to burn coal and have bottom ash and fly ash (particulate) handling equipment.

Boiler exhaust gases should be monitored and controlled by an electrostatic precipitator or equivalent device. Although boiler particulate emissions when burning shredded waste as a supplemental fuel

TABLE 64

WILMINGTON, DELAWARE, SYSTEM TIME AND COST SCHEDULE

Activity	Time period	Total cost (dollars)	Federal share of cost (dollars)
Design	March 1974 to June 1975	1,400,000	916,560
Construction	July 1975 to May 1977	10,500,000	6,862,640
Operation and evaluation	June 1977 to May 1978	1,860,000	1,220,800
Total		13,760,000	9,000,000

*The State of Delaware is to provi[illegible] $4.76 million as its share of the financing.

TABLE 65

WILMINGTON, DELAWARE, SYSTEM OUTPUT

Product	Quantity (tons*)	Value (dollars/ton)
Humus (compost)	16	14.70
Solid waste fuel	15	†6.00
Ferrous metal	7	18.00
Nonferrous metal	1	240.00
Glass	7	7.00
Paper	1	10.00
Pyrolysis gas	11	2.18

*Per 100 tons of solid waste input.

†Gross fuel savings without recovery of cost; assumes waste fuel heat value of 5,000 British thermal units per pound and cost of fuel oil of $1.00 per 10^6 British thermal units.

TABLE 66

WILMINGTON, DELAWARE, PROJECTED SYSTEM ECONOMICS*

Item	Value
Capital investment (millions of dollars)	11.20
Annual costs (millions of dollars):	
Amortization and interest	1.40
Operation and maintenance	1.52
Total	2.92
Cost before revenue (dollars/ton of input waste)	22.40
Revenues (dollars/ton of input waste):	
Humus	2.35
Solid waste fuel	.57
Ferrous metal	1.25
Nonferrous metal	2.40
Glass	.49
Paper	.10
Total	7.16
Net cost (dollars/ton)	15.24

*130,000 tons of raw solid waste are throughput per year.

may be greater than when oil alone is fired, particulate emissions should be controlled to meet local and Federal standards. Any process water effluents should be [illegible] and controlled to meet local and Federal standa[illegible]

The projected system economics is summarized in Table 66.

WET PULPING FOR MATERIAL RECOVERY FRANKLIN, OHIO

The Black-Clawson Company has operational responsibility for this system. The objective of this project is to demonstrate a refuse disposal and resource recovery system capable of processing municipal refuse and producing metals, color-sorted glass, and paper fiber in a recyclable form. Nonrecoverable combustible materials are incinerated in a fluidized bed reactor. The time and cost schedule for design, construction, and operation is given in Table 67.

The total system, with a design capacity of 150 tons per 24-hour day, contains three subsystems for solid waste disposal, fiber recovery, and glass recovery. The disposal system consists of a Hydrapulper, a wet grinder that pulps the incoming refuse except for large objects, which are ejected and passed through a magnetic separator to recover the ferrous metal portion. A liquid cyclone takes the pulped waste from the Hydrapulper and extracts small heavy objects, mostly glass intermixed with some metals, wood, and plastic. The remaining pulp passes from the liquid cyclone into a fiber recovery subsystem, where the pulp undergoes further cleaning and dewatering. The final product is a low-grade paper fiber suitable for recycling. Rejected fibrous material is piped to a fluidized bed incinerator for disposal. This fluidized bed incinerator is also being used to

TABLE 67
FRANKLIN, OHIO, SYSTEM TIME AND COST SCHEDULE

Phase and activity	Time period	Total cost (dollars)	Federal share of cost (dollars)
Hydrasposal and fiber recovery systems:			
Design	March 1969 to February 1970	165,000	110,000
Construction	March 1970 to June 1971	1,970,000	1,300,000
Operation and evaluation	June 1971 to August 1972	500,000	350,000
Subtotal		2,365,000	1,960,000
Glass and aluminum recovery system:			
Design	July 1971 to May 1972	20,000	14,000
Construction	May 1972 to July 1973	360,000	240,000
Operation and evaluation	July 1973 to July 1974	90,000	60,000
Subtotal		470,000	314,000
Total		*3,100,000	2,100,000

*The city of Franklin is to provide $500,000, the Black-Clawson Company is to provide $200,000, and the Glass Container Manufacturers Institute is to provide $150,000 of the non-Federal share.

TABLE 68
FRANKLIN, OHIO, SYSTEM OUTPUT

Product	Quantity (tons*)	Price (dollars/ton)
Ferrous metal	7	13.50
Paper fiber	13	25.00
Glass: color sorted	5	12.00
Aluminum	.4	200.00

*Per 100 tons of solid waste input.

dispose of sewage sludge from an adjacent sewage treatment plant.

Heavy material extracted by the liquid cyclone will be piped to the glass recovery subsystem. The subsystem will use magnetic separation, screening, air classification, and optical sorting to produce an aluminum-rich concentrate and color-sorted glass. Organic rejects may prove useful as a fuel source. System outputs are shown in Table 68.

It should be noted that about 10 tons of solid residuals (per 100 tons of solid waste input) must be landfilled. Air emissions from the fluid bed incinerator have been found to be below the Federal standards. All water effluents from the plant are discharged for treatment into the adjacent sewage treatment plant.

The projected system economics is summarized in Table 69.

TABLE 69
FRANKLIN, OHIO, PROJECTED SYSTEM ECONOMICS*

Item	Value
Capital investment (dollars)	8,300,000
Annual costs (dollars):	
Amortization and interest	800,000
Operation and maintenance	1,500,000
Total	2,300,000
Cost before revenue (dollars/ton of input waste)	15.10
Revenues (dollars/ton of input waste):	
Ferrous metal	.85
Paper fiber	3.75
Glass: color sorted	.50
Aluminum	.80
Sewage sludge disposal credit	.60
Total	6.50
Net cost (dollars/ton)	8.60

*Based on a 3-shift, 500-ton-per-day operation in which 150,000 tons of raw solid waste are throughput per year.

PYROLYSIS TO PRODUCE FUEL OIL– SAN DIEGO COUNTY, CALIFORNIA

The County of San Diego has operational responsibility for this system and will build a 200-ton-per-day solid waste energy recovery plant (Table 70). Its key

TABLE 70
SAN DIEGO COUNTY, CALIFORNIA, SYSTEM TIME AND COST SCHEDULE

Activity	Time period	Total cost (dollars)	Federal share of cost (dollars)
Design	April to December 1973	278,660	122,244
Construction	January 1974 to April 1975	2,866,277	2,304,693
Operation and evaluation	May 1975 to April 1976	867,773	535,773
Total		*4,012,710	2,962,710

*San Diego County is to provide $600,000, Garrett Research and Development Company is to provide $300,000, and San Diego Gas and Electric Company is to provide the remaining $150,000 of the non-Federal share.

component will be a flash pyrolysis unit developed by the Garrett Research and Development Company. Mixed municipal solid waste will be coarsely shredded to a 3-inch particle size and then separated mechanically into two fractions: a "light" fraction consisting of paper and plastic and a "heavy" fraction consisting of glass, metals, wood, and stones. The light material will be dried and shredded to a very fine particle size (practically a powder) prior to flash pyrolysis at a temperature of about 900° F. An oillike liquid with a heat value about 75 percent that of No. 6 fuel oil will be condensed from the pyrolysis gases. The oillike liquid will be used as supplementary fuel in an existing San Diego Gas and Electric Company boiler.

The heavy waste fraction will be processed further to separate ferrous metals and glass. Ferrous metals will be separated by an electromagnet. Glass will be separated as a mixed-color glass cullet by a froth flotation process (Table 71).

TABLE 71
SAN DIEGO COUNTY, CALIFORNIA, SYSTEM OUTPUT

Product	Quantity*	Price
Oil	100 barrels	$2.27 per barrel
Ferrous metal	7 tons	$18 per ton
Glass	5 tons	$6 per ton

*Per 100 tons of solid waste input.

It should be noted that 7 tons of char (per 100 tons of solid waste input) will require landfilling. Exhaust gases will be monitored and controlled to meet local and Federal standards, and wastewater will be discharged into a sanitary sewer.

This system requires no external fuel and produces a storable, transportable fuel that should have good national marketability; however, raw waste must be shredded to a very fine particle size.

The projected system economics is summarized in Table 72.

PYROLYSIS FOR STEAM GENERATION—BALTIMORE, MARYLAND

Baltimore will own and operate a 1,000-ton-per-day solid waste pyrolysis plant developed by Monsanto Enviro-Chem Systems, Inc. The LANDGARD

TABLE 72
SAN DIEGO COUNTY, CALIFORNIA, PROJECTED SYSTEM ECONOMICS*

Item	Value
Capital investment (dollars):	2,748,000
Annual costs (dollars):	
Amortization and interest	264,742
Operation and maintenance	420,732
Total	685,474
Cost before revenue (dollars/ton of input waste)	9.79
Revenues (dollars/ton of input waste):	
Oil	2.27
Ferrous metal	1.28
Glass	.32
Total	3.87
Net cost (dollars/ton)	†5.92

*Based on a 200-ton-per-day operation in which 70,000 tons of raw solid waste are throughput per year.

†A more conservative analysis undertaken by Midwest Research Institute estimated the net cost per ton for a 1,000-ton-per-day plant to be $5.42.

TABLE 73
BALTIMORE, MARYLAND, SYSTEM TIME AND COST SCHEDULE

Activity	Time period	Total cost (dollars)	Federal share of cost (dollars)
Design and construction	January 1973 to July 1974	15,852,000	6,000,000
Operation and evaluation	August 1974 to November 1975	325,000	0
Total		*16,177,000	6,000,000

*Baltimore is to provide $6,177,000 and Maryland Environmental Services is to provide $4 million of the non-Federal share.

system will be designed and constructed by Monsanto under a turnkey contract with moneyback performance guarantee provisions. Monsanto is guaranteeing plant availability at 85 percent, particulate emissions to meet local and Federal standards, and the residue putrescible content to be less than 0.2 percent. Monsanto's maximum payback liability is $4 million, about 25 percent of the contract price. The time and cost schedule for design, construction, and operation is given in Table 73.

The plant is being designed to handle mixed municipal solid waste, including tires and white goods. All incoming waste will be shredded to a 4-inch particle size and then conveyed to a rotary pyrolysis kiln. About 7.1 gallons of No. 2 fuel oil per incoming ton of waste will be combusted to provide heat for the pyrolysis reaction. In addition, about 40 percent of stoichiometric air will be added to the reactor to allow some of the pyrolysis gases to combust and add additional heat to the unit. The pyrolysis gases leave the kiln and will then be combusted in an afterburner. The hot afterburner exhaust gases will pass through waste heat boilers that generate 200,000 pounds of steam per hour for sale to the Baltimore Gas and Electric Company (Table 74). The steam will be used for downtown heating and cooling. Boiler exhaust gases will be scrubbed, dehumidified, and released to the atmosphere.

The pyrolysis residue will be water quenched and ferrous metals will be separated. Water flotation and screening processes will separate the char residue, which must be landfilled (16 tons, with 50 percent moisture, for every 100 tons of solid waste input), from a glassy aggregate fraction, which will be used as aggregate for city asphalt concrete street construction.

Air emissions will be monitored and controlled to meet local and Federal standards; there will be no wastewater discharged.

The technological risk in this system is not great because of the simplicity of the process and adequate pilot plant testing. Unfortunately, in general, steam is

TABLE 74
BALTIMORE, MARYLAND, SYSTEM OUTPUT

Product	Quantity (tons*)	Price (dollars/ton)
Steam	240	1.62
Ferrous metal	7	7.00
Glassy aggregate	17	2.00

*Per 100 tons of solid waste input.

TABLE 75
BALTIMORE, MARYLAND, PROJECTED SYSTEM ECONOMICS*

Item	Value
Capital investment (dollars)	15,371,000
Annual costs (dollars):	
Amortization and interest	1,480,000
Operation and maintenance	1,774,000
Total	3,254,000
Cost before revenue (dollars/ton of input waste)	10.50
Revenues (dollars/ton of input waste):	
Steam	3.57
Ferrous metal	.44
Glassy aggregate	.34
Total	4.35
Net cost (dollars/ton)	6.15

*Based on a 1,000-ton-per-day operation in which 310,000 tons of raw solid waste are throughput per year.

TABLE 76

LOWELL, MASSACHUSETTS, SYSTEM TIME AND COST SCHEDULE

Activity	Time period	Total cost (dollars)	Federal share of cost (dollars)
Design	February 1973 to March 1974	430,000	325,000
Construction	March to December 1974	1,912,000	1,434,000
Operation and evaluation	January to December 1975	835,000	625,000
Total		*3,177,000	2,384,000

*The State of Massachusetts is to provide $615,000 and the city of Lowell is to provide $178,000 of the non-Federal share.

not an easy product to market because it cannot be stored or transported for long distances. Another drawback of this system is its use of about 7.1 gallons of No. 2 fuel oil per ton of incoming waste. However, the steam generated will conserve 39.1 gallons of fuel oil per ton of incoming waste, for a net savings of 32 gallons per ton of waste processed.

The projected system economics is summarized in Table 75.

INCINERATOR RESIDUE SEPARATION–LOWELL, MASSACHUSETTS

The principal objective of this project will be to demonstrate that the components of incinerator residue can be separated and economically recovered.

The city of Lowell will build a full-size processing plant capable of handling 250 tons of incinerator residue in 8 hours (Table 76). Raytheon Service Corporation has the operational responsibility for the first year; thereafter, responsibility may be transferred to the city of Lowell. Residue from Lowell and several neighboring communities will be processed in the facility. The plant will be designed by the Raytheon Company using the system piloted by the U.S. Bureau of Mines at College Park, Maryland. Using a series of screens, shredders, classifiers, and other ore beneficiation equipment, the plant will extract more than 40,000 tons of products–steel, nonferrous metals, and glass–from the incinerator residue annually (Table 77). Revenue from the sale of the products is expected to exceed $700,000 a year (Table 78). The net profit may be used to offset increasing incineration costs or air pollution control costs.

It should be noted that depending on the level of burnout in the incinerator residue, about 5 tons of solid residuals (per 100 tons of incinerator residue input) must be landfilled. There will be no gaseous pollutants emitted from the processing plant, and

TABLE 77

LOWELL, MASSACHUSETTS, SYSTEM OUTPUT

Product	Quantity (tons*)	Price (dollars/ton)
Ferrous metal	30	10
Aluminum	2	200
Copper/zinc	1	330
Glass	30	10
Aggregate	32	2

*Per 100 tons of incinerator residue input.

TABLE 78

LOWELL, MASSACHUSETTS, PROJECTED SYSTEM ECONOMICS*

Item	Value
Capital investment (dollars)	1,740,000
Annual costs (dollars):	
Amortization and interest	167,000
Operation and maintenance	536,000
Total	703,000
Cost before revenue (dollars/ton of input waste)	10.80
Revenues (dollars/ton of input waste):	
Ferrous metal	2.40
Aluminum	3.00
Copper/zinc	3.30
Glass	2.00
Aggregate	.50
Total	11.20
Net profit (dollars per ton)	.40

*Based on a 1-shift, 250-ton-per-day operation in which 65,000 tons of raw solid waste are throughput per year.

process water will be treated in the plant before being discharged into Lowell's sanitary sewer system.

The reliability and efficiency of the material separation system must be validated, and product quality and marketability will be demonstrated.

RESOURCE RECOVERY RESEARCH

Most of the Federal resource recovery research funds have been expended on the development of an on-site electrical conversion scheme. The system, the CPU-400, is being developed by Combustion Power Company of Menlo Park, California. All of the funding for the project, which will exceed $6 million by December 1973, has been provided by the Federal Government since its beginning in 1967.

The planned conversion of solid waste to electricity begins with the combustion of the burnable solid wastes. The exhaust gases of combustion will directly drive a gas turbine, which in turn will drive an electrical generator. Before entering the delicate turbine, the exhaust gases must be thoroughly cleaned. The cleaning process must produce an exhaust gas that is at least 10 times as clean as exhaust allowed by Federal regulations for municipal solid waste incinerators. The high standard is felt necessary to protect the turbine blades from erosion and corrosion.

For several years, cleaning the exhaust gases has proven to be one of the major technical hurdles. Another is the ability to control the turboelectric system. Recent tests have identified a new technical problem, buildup of deposits on the turbine blades.

RESOURCE RECOVERY COMPONENT DEVELOPMENT

In addition to development of full-scale demonstration systems, the Federal Government has also sponsored development of components. The major efforts include the following:

(1) *Solid waste separator.* A grant of $135,000 was given to the Franklin Institute in Philadelphia, Pennsylvania, to develop a ballistic separator that would mechanically separate shredded refuse. The system was designed to recover mixed paper fiber for sale. Matching funds were provided by the Franklin Institute and Sickson Paper Fibres, Inc. The project was successfully completed on March 31, 1972.

(2) *Classification of nonmagnetic metals.* A grant of $435,481 was given to Vanderbilt University to develop high-energy electromagnetic separators to separate nonferrous metals. Several different types of electromagnetic separators were evaluated. The project ended on June 30, 1972. Equipment developed during the project is now being used to extract chromed zinc from mixed nonferrous metal at an automobile shredding plant in Nashville, Tennessee.

Appendix B

PRODUCT DESIGN MODIFICATIONS FOR RESOURCE RECOVERY, SOURCE REDUCTION, OR SOLID WASTE MANAGEMENT PURPOSES

The purpose of this appendix is to provide a very preliminary conceptual review of a number of product design considerations that appear to be relevant to various aspects of solid waste management. The common element and focus is that of product design, although it will become readily apparent that aspects of product utilization by consumers and post-consumer systems of disposal and/or recovery can seldom be ignored in analyzing the product attributes at issue.

The product attributes selected for discussion are the following: (1) recyclability, (2) recovered (secondary) material content, (3) economic durability, (4) reusability, (5) potential for causing external damage from disposal, (6) degradability in natural environments. The first two of these relate primarily to questions of resource recycling and recovery, the third and fourth to issues of solid waste source reduction (aside from recovery possibilities), and the last two to direct social and/or ecological damage from disposal.

In the following sections each of these product design attributes will be defined, and the social significance, technical feasibility, potential solid waste management impact, and importance for policy consideration will be reviewed. It should be stressed that this is a preliminary attempt to organize and review these concepts and that the necessity or desirability of product design changes of this type has not been established.

It should be recognized that public intervention to regulate any of the six product attributes could itself take a wide variety of forms—from direct administrative regulation or the development of product standards (including bans as a special case) to various indirect tax or subsidy inducements. This appendix does not attempt to devise or analyze these specific control approaches, or to assess the need for such control, but rather concentrates on the technical and other issues that need to be better understood prior to the policy formulation process.

PRODUCT RECYCLABILITY

"Recyclability" is a very general term relating to the relative technical ease or feasibility of recovering a particular material from products that would potentially enter the post-consumer solid waste stream. This implies the recovery of particular metals as metals and fiber from paper or paperboard as fiber, as opposed to extraction of energy values from combustible material, the conversion of carbonaceous material into hydrocarbon fuels or compost, or the conversion of various material combinations into construction aggregates or other "by-product" material use applications.

Recyclability is an inherently relative concept because ease of recovery depends on a host of factors relating not only to the existence of specialized recovery technology but also to conditions of product disposal as waste, collection systems, and consumer industry capabilities. It is, therefore, very difficult to deal with at a general level, even in purely technological terms, and is also obviously subject to significant changes in interpretation over time. The following is a list of some of the ways that product designs might conceivably be altered to enhance recyclability: (1) the ease of mechanical disassembly of complex products (such as automobiles or appliances) might be increased, (2) the identifiability of specific chemical compositions of complex materials might be improved (i.e., some sort of "tracing" mechanism or material labeling aid might be incorporated into fabricated materials), (3) materials might be standardized, (4) the chemical/physical separability of complex materials might be increased, (5) products might be made of materials that would cause smaller contaminant problems (e.g., substitution of aluminum for copper in automobiles).

Social Significance

Recyclability is broadly related to all the social concerns regarding the efficiency of material utilization including direct costs and environmental impacts of post-consumer waste disposal, conservation of particular natural resource supplies, and net environmental impacts of virgin material industries in comparison with alternative secondary material recovery systems.

It would appear that the proximate objectives (or social benefit values) of increased recyclability relate to either (or both) decreased cost of secondary material supply (including especially the costs of separation and sorting) and improved-quality characteristics of secondary materials from post-consumer sources. Thus, in particular cases, positive impacts can occur on both the demand and supply sides of secondary material markets.

To the extent that scrap values of consumer goods are increased, there could also be positive secondary results: diversion of certain items from municipal collection/disposal systems and possible reduction in littering (such as of large appliances and automobiles).

Technical Feasibility

In general, this requires a product-by-product approach and also a design-item-by-item approach. It also is apparent that product design for improved recyclability cannot productively be undertaken in isolation from knowledge about product utilization and prospective recovery systems. In other words, the total product/material cycle must be viewed as an integrated whole. This is obviously easiest to do in situations where the consumer of the recycled material is also the designer of the product, as might be expected in the case of glass containers. It seems greatly complicated, however, in the case of very long-lived durable goods, where redesigned products do not appear in the product discard stream in significant volume until many years (perhaps decades) later.

It is felt that some technically feasible options for enhancing recyclability must in all probability exist for virtually all relevant products. The productivity or effectiveness of various redesign possibilities in terms of actually increasing recycling rates will require broader systems analysis.

Practical Maximum Impact on Problems

Product design to enhance recyclability is relevant to some extent to the paper, metal, glass, rubber, and thermoplastic fraction of collected municipal waste, which together comprise somewhere between 50 and 80 percent of the waste stream according to most composition estimates. It is also relevant to automobiles. However, some significant proportions of each of these materials in waste already occur in relatively "pure" forms (e.g., glass bottles and newsprint) that are already readily recyclable insofar as product design aspects are concerned. An initial task would be to isolate these fractions to determine the remaining proportions of product/materials for which design aspects constitute a recycling bottleneck.

It is obviously very difficult to judge or predict the practical maximum increases in recycling that could result from product redesign to overcome recycling bottlenecks. However, as a very crude exercise in exploring potentials, Table 79 illustrates how one set of assumptions might translate into reductions in municipal waste disposal and virgin raw material commodity consumption.

Thus, if we could design policies for improving recyclability that could be expected to yield the increases in actual recycling shown in Table 79, total municipal waste disposal requirements would be reduced by about 16 percent on a dry weight basis (assuming 100 million tons per year as the national base) or about 13 percent on the alternative wet weight basis (assuming 150 million tons per year as the national base). Correspondingly, we can crudely estimate virgin material demand displacement on the order of 14 percent of wood fiber, 2 to 3 percent of refined metals, over 50 percent of virgin rubber (mostly synthetic hydrocarbons), and 50 percent of manufactured glass. Clearly the reduction in environ-

TABLE 79

ESTIMATE OF PRACTICAL MAXIMUM IMPACT OF INCREASED MATERIAL RECYCLING ON ANNUAL MUNICIPAL WASTE DISPOSAL AND VIRGIN MATERIAL DEMAND

Type of material	Weight (dry) in municipal waste, 1968 (10^6 tons)	Percent by wet weight of total municipal waste, 1968	Annual U.S. consumption of virgin material (10^6 tons)	Assumed possible recycling increase		Reduction in total municipal waste disposal as a result of increased recycling (percent)		Reduction in virgin material demand as a result of increased recycling (percent)
				Percent of material in waste	Weight (10^6 tons)	Dry	Wet	
Paper and board	40	40	44	15	6.0	6.0	6.0	13.6
Metal	12	8	93	20	2.4	2.4	1.6	2.6
Rubber tires	2	1.3	3	80	1.6	1.6	1.1	53.3
Glass	12	8	12	50	6.0	6.0	4.0	50.0
All other	34	44	—	0	0	0	0	0
Total:								
Dry	100	—	152	—	16.0	16.0	—	—
Wet	150	100	—	—	—	—	12.7	—

mental impacts implied by these figures would not be insignificant.

It is unlikely that there would be any conceivable impact on littering of packaging material or other nondurable goods from increasing recyclability. However, for large items such as automobiles and major household appliances, it is conceivable that if scrap values were increased, unregulated dumping on private or public property might be measurably reduced.

Importance for Public Policy Consideration

It seems evident that policies for encouraging increased "recyclability" of products represent an important and viable area for further consideration. To be effective and equitable, a product-by-product approach seems essential. This will require considerable technical expertise and awareness of product use patterns and viable recovery systems as well as of product production itself.

This may be an area where voluntary industry action might be capable of achieving much of the potential benefits without formal regulatory intervention. Given the complexity of regulation in this area and the potential for making costly mistakes in policy, good technical research and development and information programs for evaluating viable options and making them widely known to industry groups might be a worthwhile short-term approach. Federal procurement possibilities could offer a more forceful approach, short of direct intervention, into specific product markets. Product redesign to improve the ease with which recycling may occur, however, represents only one set of variables in the overall system determining the viability of recycling. Therefore, it may be best to consider this as one aspect in an overall approach to specific industries or products.

RECYCLED CONTENT OF PRODUCTS

For present purposes, the recycled content of products is defined broadly to include any secondary material derived from either post-consumer residuals, converter-fabrication sources, or other sources, exclusive of "home-scrap" types of residuals recycled internally in mill operations. The recovered material may enter the product flow stream at any point from the basic material processor (e.g., an integrated iron and steel mill) to the final product or container manufacture or assembly. The term "products" is used synonymously with "physical goods" and may be defined to include either or both final goods or intermediate (semifinished) goods.

The complexity of potential policy formulation in this area is illustrated by the following possible variations in policy design options: (1) degree of product detail–broadly defined product categories ("construction materials" or "consumer durables") or narrowly defined items or product components (automobile engine blocks, book paper, copper wiring, beverage bottles, or cans); (2) degree of secondary material substitution specificity–very general ("secondary material," in general, without regard to type or source) versus very specific (secondary copper for virgin copper, secondary aluminum for virgin aluminum, automobile steel scrap for virgin steel, or aluminum can scrap for virgin aluminum); (3) specificity of secondary material source–either, post-consumer versus converter type, household versus commercial source, specified geographical area source, or specified product source (e.g., "paper" versus newsprint and aluminum versus aluminum cans).

It goes without saying that any policy that increases recycling will increase the secondary material content of some product(s). We are, therefore, concerned here with policies that are focused directly at product producers (either final or intermediate goods) and, therefore, operate by stimulating the demand for materials or energy recovered from waste streams.

Social Significance and Objectives

The principal focus of secondary material content regulation is on the market demand side of secondary material utilization. The objective is to increase resource recovery flows out of the solid waste stream. As such, the higher level objectives are those of resource recovery in general: (1) reduction of direct budgetary costs of solid waste disposal (and also of collection attributable to wastes), (2) reduction of residual environmental damages of solid waste disposal, (3) reduction of environmental damage from virgin material supply, (4) reduction of present demands on virgin material natural resources to increase future availability and/or reduce future material costs.

Technical Feasibility

Increasing recycled content can refer to both "pure recycled" ratios for specific materials and the substitution of secondary materials in nonrecycle-type uses (e.g., glassphalt and construction materials from incinerator residues) and substitutions of one specific recovered material for another specific virgin material in various product-use applications.

The "maximum" potential is not known or knowable for the subject as a whole. There are too many possible variations to explore all technical possibilities. A key aspect in technical feasibility, however, is the potential material and product performance attributes that might be affected, the types of changes that could be considered socially or economically "acceptable," and the types of constraints that might be set on allowable degradations in product quality or performance aspects. This can be an extremely technical set of issues. It also has a number of obvious social welfare aspects relating to health and safety of products, product durability, and consumer utility.

Practical Maximum Impact

From the solid waste management point of view, current technology is probably available to utilize virtually 100 percent of all municipal solid waste in some kind of product application if we define the latter broadly to include energy conversion, construction materials, and "productive" construction landfill in addition to the standard (higher value) material recycled applications. Thus, municipal waste disposal costs and environmental impacts could be reduced to zero. All of these uses would involve displacement of some virgin-based material, but many would not have high conservation values. Further, many would be single-use types of material reuse (e.g., energy recovery) as opposed to the multiple reuse potential in recycling. Total potential for reducing environmental impacts of virgin material supply would be extremely difficult to estimate—impossible to estimate until a detailed specific set of policy targets is postulated. Litter could be substantially reduced as a side effect of a maximally imposed policy.

Importance for Public Policy Consideration

This inroad has very significant potentials for increasing material recovery. It will, however, require very careful policy design to minimize costs, which could be significant.

It is accordingly important to realize that most major industries are likely to be affected, and that implementation of a regulation requiring recycled content could displace certain industrial operations in specific regions. Marginal virgin material suppliers could also be forced out as a result of a regulation of this type.

ECONOMIC DURABILITY OF PRODUCTS

"Economic durability" or "product lifetime" refers to the length of time household consumer goods remain in the household sector stock (or inventory) from time of purchase as new items to time of final discard to either waste disposal or material recycling. Lifetime within the household sector inventory often involves sequential ownership transfers from original purchaser to second- and possibly third- and fourth-generation owners. It often also may involve a nonuse phase following its active service life during which it is simply held as a standby item for emergency use, retained as a source of spare parts, or stored to avoid time and cost of transporting to a disposal site.

For present purposes discussion is limited to durable goods only. Household "convenience" items such as paper towels and paper and plastic throwaway tableware have been excluded from consideration in this section as have reusable containers.

Product lifetime is a relatively complex attribute of durable goods. It is dependent not only on functional durability aspects of original design but also on conditions of use and maintenance performed. Furthermore, it is dependent on sociological and economic factors such as consumer preferences, stylistic obsolescence, cost of replacement goods, income differences among households, ease and cost of repair as an alternative to replacement, household space limitations, and possibly also cost of disposal.

Social Significance

The primary significance of product lifetime to issues of solid waste management, resource conservation, and environmental quality resides generally in its relationship to the total throughput flow of materials and products with respect to production requirements, current stock of service-providing durable goods, and final disposal flows. However, this relationship is itself rather complex, and, therefore, the implications of a change in product lifetime for the stock flow relationships in question are not entirely clear-cut or obvious.

For purposes of illustration, consider a steady state (non-economic-growth) situation described schematically by

$$P \rightarrow S \rightarrow D$$

where

P = current annual purchases or production of a given durable good

S = the stock or inventory of the good

D = the current annual discard flow to disposal and/or recycling

In equilibrium, the system can be described mathematically by the following simple relationships:

(1) S is constant over time, as are both P and D.

(2) $S = \alpha P$ where α = the average lifetime of the product.

(3) $P = D = S/\alpha$ (i.e., current purchases equal current discards; and if the average lifetime of a product is, say, 10 years, both P and D will equal 1/10 of the current stock).

Now assume that somehow there occurs an increase in the product's average lifetime by $\Delta\alpha$, from α_1 to α_2. In principle, there are two possible extreme adjustment patterns that could be associated with this change in lifetime:

(1) Consumers could maintain their current purchase flow P and allow their stock to increase by the maximum quantity of $\Delta\alpha P$. In this new equilibrium situation, P and D remain unchanged and S is increased.

(2) A second extreme case would be where consumers desire to maintain their same stock level under the changed lifetime conditions. In this case, the new equilibrium would find both P and D reduced by $1 - \alpha_1/\alpha_2$ of their original values.

Apparently, if consumers have the option of adjusting both S and P, the outcome will be somewhere between the extremes; the most that can be said is that an increase in average lifetime will lead to an increase in stocks and a decrease in P and D, by amounts less than their maximum individual potentials under the changed lifetime assumed. As a practical matter, this indicates that the prediction of flow (P and D) implications with respect to a change in lifetime requires more than simply a priori knowledge of the change in lifetime. The most that one can argue is that an increase in lifetime should not increase P and D. The extent to which P and D are reducible by an increase in lifetime will require specific knowledge of behavioral adjustment processes relating to stockholding decisions on the part of consumers.

The dynamic case involving the growth of population and consumer incomes provides a more complex relationship from a mathematical standpoint, but it can be modeled. However, the essential conclusions regarding predictability derived from the steady state theory remain essentially unchanged.

As a solid waste source reduction contributor, change in product lifetime could have widely pervasive effects on all the objectives of solid waste management and resource recovery. In general, it is akin to a decrease in total consumption or economic growth from the standpoint of material throughput requirements. Because it can have impacts on both new goods purchases and discard flows, an increase in product lifetime could reduce litter rates (durable goods); solid waste management collection and disposal costs; material availability for resource recovery industries; demands on natural resources and energy systems for production of new goods; and environmental impacts of post-consumer waste disposal, virgin material and converting industries, and secondary material recovery industries.

Technical Feasibility

It is technologically possible to redesign products for increased durability and ease of maintenance and repair although it is difficult to generalize in this regard. Some possible ways that product lifetime might be increased include (1) increased physical durability obtained through better construction by means of more material or different material, design to reduce the number of moving parts, and design to increase ease and/or decrease cost of maintenance; (2) increased ease of repair and reduced cost of repair through design; (3) decreased rate of product design change (decreased frequency of design change and/or extent of change) with respect to either or both style and fashion and performance. Most or all of these would also tend to enhance the relative position of second-hand goods vis-a-vis new goods.

Practical Maximum Impact on Problems

All household durable goods currently comprise probably no more than 10 to 15 percent of collected solid wastes. National Industrial Pollution Control Council data indicate that major household appliances contributed about 2.2 million tons per year in 1971 to the Nation's solid waste stream. This is less than 2 percent of municipal waste by tonnage or compacted volume. It is important to note also that durability increases will not eliminate but only reduce waste flows. The effect will also only begin to occur some years after policy initiation (e.g., the average for nonrecycled automobile scrap waste would be 5 to 10 years later).

The effect on littering (e.g., abandoned automobiles and appliances) would be positive, but not readily measurable.

Resource conservation effects will be largely postponed until the replacement time period for new goods has elapsed. There could be some short-term adverse effects to the extent that redesign involves higher material weight and/or substitution of more scarce materials to achieve durability. The maximum impact in the long run could be very important, both domestically and worldwide.

Public Policy Considerations

Increasing product lifetimes is inherently a long-term approach; there is not likely to be a short-term impact, except possibly in second-hand goods or repair market short-term applications, and only to the extent that such a measure directly improves the function of the second-hand goods market. Maximum potential impacts on resource conservation could be very significant, and this would probably be its major impact in terms of social benefits.

This strategy should not be approached in isolation from other product redesign issues and objectives with respect to durable goods. For example, to the extent that lifetime increases involve more weight of product (e.g., automobiles), fuel for operating might be increased and waste disposal benefits could be partially offset.

Longer lifetime of durable goods, in general, implies less flexibility in terms of being able to influence performance and operating characteristics of the in-use stock of assets. For example, the introduction of emission control or fuel energy economy aspects into automobiles would be easier if the average lifetime of automobiles were 5 years instead of 10 years.

PRODUCT REUSABILITY

This topic is concerned with the broad and increasing category of consumer and producer goods that are designed for one use only but that, in principle, could be designed for multiple uses in serving the same function. Indeed, most of the products in this category compete currently with multiple-use substitutes (e.g., paper towels versus cloth towels and refillable versus nonrefillable containers).

As is obvious, this category could well be regarded as a special class within the "economic durability" or product lifetime subject. We treat it separately to give special emphasis to the nondurable and semidurable goods aspects. We do not intend to develop at this time the further special case of reuse for different function (e.g., the employment of used automobile tires as playground equipment or of automobile bodies in underwater reef construction).

Social Significance

In general, the discussion for economic durability applies here as well. Essentially, we can regard single-use commodities as being utilized in "pure flow" systems, with an in-use stock of service-yielding assets of virtually zero. In this sense, a doubling of the number of uses for a given item (from one to two) will, other things being equal, reduce current purchases and discards by half. "Number of uses" thus becomes analogous to "number of years" for durable goods in the economic lifetime discussion.

The same general implications for solid waste disposal costs, resource conservation, and environmental protection apply here as well. This topic, however, has considerably more direct and indirect relevance to the litter problem.

Technical Feasibility

Design for reusability is obviously only one aspect of the broader system that determines actual reuse patterns. The latter includes the behavior of users as well as the system of incentives that influences behavior. It also includes industrial organization and technology relating to reuse cycles outside of households or primary user establishments (e.g., collection systems and sorting and cleaning as for refilling containers.)

Data collected on packaging in general and specifically beverage containers may be found in Chapter 5. However, as with some of the other topics in this series, there appear to be a number of general possibilities, including: (1) substitution among existing products (e.g., cloth towels for paper towels and refillable bottles for nonrefillable bottles and cans), (2) design of containers to be refillable, (3) product redesign to increase durability and reusability (e.g., reusable paper towels), (4) product redesign explicitly for reuse (e.g., corrugated shipping containers designed expressly to be easily "taken down" (without destroying the container) and returned to the shipper or to an independent wholesaler—such cartons are currently employed by some moving companies), (5) design of nonfoldable containers to be stackable as a means of reducing storage space and return shipping costs (e.g., wooden fruit baskets).

There are a number of current options that are demonstrated (by currently available substitutes) to be technically feasible on the product design side of the system.

Practical Maximum Impact on Problems

Empirical data have not yet been surveyed and integrated to get a good quantitative estimate of impact. The breadth of product categories complicates this task. However, it seems evident on cursory overview that the potential impact on solid waste management will be greater for this category than for the product lifetime category of consumer durable goods. The major impact will be on paper, paperboard, glass, and plastics, with some impact also on metals (steel and aluminum).

Importance for Public Policy Consideration

The reusability approach appears to be a very significant topic both from solid waste management and resource conservation viewpoints. Significant problems may occur in designing optimal policy strategies and in gaining industry and consumer acceptance, however.

PRODUCT POTENTIAL FOR DISPOSAL DAMAGES

This topic relates to the potentials of various products for causing economic, human health and safety, or specific ecological damages under various disposal conditions. In one way or another, the topic is concerned with products that are in some sense "hazardous"—either inherently because of their toxic material content or their content that can become hazardous or damaging when disposed of in ways such as by incineration or by dumping into water.

Social Significance

The social objective is to reduce the damages associated with the waste disposal of the particular products. The damages may be more or less strictly economic (e.g., incinerator repair or replacement costs); they may relate to public health and safety, with both economic and paraeconomic aspects; or they may relate to socially perceived damages to other biological species or ecosystems.

Technical Feasibility

In most instances, either material content substitutions in products or structural product or component redesign represents viable possibilities for either eliminating or significantly reducing problem causes. In special cases product (or material content) bans may be the only feasible means of eliminating a problem, with other source-reduction-type standards or some degree of direct regulatory control over use being a partial control alternative. The subject has not yet been sufficiently researched to evaluate technical feasibility through product redesign.

Practical Maximum Impact on Problems

Particular problems of hazards and other damage potentials from post-consumer solid waste disposal need to be defined and evaluated more completely in terms of their cause-effect relationships and social significance.

Importance for Public Policy Consideration

This is a rather traditional field for public regulation of particular products and materials. Many precedents exist in the fields of food and drug regulations. It is possible that many of these issues may be amenable to voluntary industry solution when well-developed cases can be made in demonstrating significant health hazards, as long as the solutions are low cost. The approach discussed in this section deserves considerable attention.

PRODUCT DEGRADABILITY FOLLOWING DISPOSAL

"Degradability" relates to the extent to which materials "decay" or break down over time when subjected to natural chemical, physical, and biological processes in the environment. Degradability is an inherently relative concept because virtually all known materials are subject to at least some measurable rate of decay under certain environmental conditions. In addition, environmental conditions such as temperature, moisture, sunlight, wind, land cover material, and biological communities are subject to wide geographic variations that can greatly affect the time rate of degradation of any given material.

The focus of the present discussion is on possibilities for reducing environmental and social damages from solid waste disposal by somehow increasing product degradation rates.

Social Significance

Degradability is primarily relevant to the problems of litter; it may also be relevant to the ecological aspects of sanitary landfill operations. It is not directly relevant to the material resource conservation objective of resource recovery or source reduction.

Litter. In our present conception, the problem of litter is essentially one of visual aesthetics and, with very minor exceptions, not one of either public health or ecological damage significance. From this perspective, the key variable insofar as product degradation is concerned is product "disappearance time." In those areas where litter is subject to pickup–chiefly major highways, high-density recreation areas, and some city streets–more rapid product degradation may conceivably have some implications for collection costs.

Sanitary Landfill. We do not yet have any well-established information on the possible implications for sanitary landfill costs or ecological consequences. Possibly more rapid degradability could improve volumetric capacities. There could also be either beneficial or damaging consequences in terms of leachates. This aspect of degradability has not yet been developed; but on a priori grounds, chemical stability or instability seems neither inherently good nor bad, and the presumption is that answers would depend on special case circumstances.

Technical Feasibility

There are essentially two broad technical possibilities for increasing the degradability of products at the design level:

(1) Substitute more degradable materials for less degradable materials in specific types of products from among presently available material substitutes (e.g., steel cans for aluminum cans and paper packaging for plastic packaging).

(2) Develop more rapidly degradable versions of current materials themselves (e.g., biodegradable plastics, photodegradable plastics or glass, and more highly water soluble paper coating and filler materials).

Three additional aspects of technical feasibility should be discussed: (1) toxicity of end products of degradation–a potentially undesirable side effect that would enter as a constraint; (2) functional utility side effects of material substitution and redesign–to the extent that products or materials become less useful or durable in their intended purposes, design for increased degradability will involve social cost side effects; (3) implications for recyclability and reusability–material degradability may often or typically be antagonistic to material recycling and/or product reuse possibilities.

Practical Maximum Impact on Problems

Litter. We suggest that there are three ways of "solving" the litter problem: (1) reduce the littering rate, (2) maintain and increase litter pickup programs (very high costs per unit or per unit volume), (3) increase degradability. Depending on circumstances, the latter may or may not contribute to a solution.

Consider first the distinction between areas subject to regular cleanup versus those subject to no cleanup (or only very random or sporadic pickup). For areas subject to regular cleanup (downtown city streets, high-density recreation areas such as public beaches and motor-camping areas, and major State highways), we offer the following general proposition: the more frequent the cleanup, the less the possible benefit of increased product degradability (either in terms of visual aesthetics or cleanup costs). For example, if pickups occur any more regularly than every few weeks, there would seem to be no possibility for degradability to contribute anything to problem solution because minimum degradability or "disappearance" times are not likely to be that short for any significant items of litter.

On the other hand, if pickup frequency is on the order of once or twice per year (the case for some lower density recreation areas), then degradability begins to have potential as a contributor to the solution roughly in proportion to some weighted average of disappearance times of the items comprising the litter. In this respect, the litter problem is never completely "solved," but average visual density is reduced, and total cost of pickup is reduced.

For areas where litter is seldom if ever systematically collected, degradable products may contribute significantly (from a visual aesthetic standpoint) in terms of reducing long-term rates of accumulation.

However, even with respect to the latter two cases of infrequent or random pickup, technical feasibility for specific product/material categories is still a point at issue. No single product/material category alone comprises more than a relatively small percentage of the total litter composition. From a technical feasibility standpoint, the "paper" category should probably more correctly be viewed as 5 to 10 different categories, no one of which comprises more than 10 percent or so of total litter. From this it is clear that even a completely successful product degradation effort for any single category as defined would have a relatively small impact on the total problem. Thus, even in the most unrealistic of all possible cases, if all plastics could be made to degrade in one day's exposure to the environment, the 6-percent impact on the litter problem would probably go unnoticed.

This implies as a practical matter that any significant impact on litter from increased product degradation will require significant decreases in disappearance times for a great many different product/material categories simultaneously.

Landfill Impacts. We simply do not yet have enough technical data at hand to evaluate this aspect of the degradation issue. Some relevant data no doubt exist but are not sufficient to form even a tentative position on policy issues at this time.

Importance for Public Policy Consideration

This is not an area in which one can expect any degree of short-term success in contributing to any problem solution. It is also doubtful that benefits to the litter problem would justify the effort.

If anything, resource recovery would likely be adversely affected by large-scale production of degradable materials. It could affect prompt industrial or converter scrap recycling as well as post-consumer material recovery potentials. If this is true, then the total material throughput of the economy could be significantly increased as an unintentional side effect; and this would have widespread adverse environmental impacts at primary material extraction and processing levels.

Appendix C

AN ANALYSIS OF THE PRODUCT CHARGE

CONCEPT

Actions of both product manufacturers and consumers have an effect upon the solid waste management characteristics of a product when discarded. Producer decisions concerning the amounts and types of materials used and decisions concerning product design parameters (e.g., durability, ease of repair, and styling) affect both the quantities of solid waste generated and the costs of collection and disposal. Consumer decisions as to the level of consumption and the choice of products impact upon solid waste in a similar manner. However, most solid waste management considerations are external to the market transactions that establish the price of products. Hence, decisions to produce or consume are made without concern for the economic and environmental consequences associated with the collection and disposal of the product after discard. This is, in effect, a market failure that could be corrected by internalizing solid waste management costs in the price of products. Such internalization would provide price signals to producers and consumers that could stimulate source reduction activities.

Another example of a market failure is the pricing of solid waste collection and disposal services. Users of such services generally do not pay in proportion to the amount of waste generated or in proportion to the level of service received. Hence, there are no price signals to the users that would lead to a reduction of such costs through a more efficient use of these services. Internalization in this area could be effected through the imposition of disposal charges at the discard level. Imposition of both product charges at the producer level and disposal charges at the discard level would result in double payment for solid waste management services. Any product or disposal charge system should be designed to eliminate or minimize this double payment.

Product charges are tools for reflecting the desired internalization of costs in the price of products. They are essentially a set of charges equivalent to the solid waste collection and disposal costs of products that are levied at the time of product sale. The objective of such charges is to provide incentives at the producer level to redesign products to reduce solid waste management costs (e.g., use less material or lighter material) and to provide incentives at the consumer level to reduce consumption. There are several other alternatives to product charges that could yield similar results including adjustment of raw material prices, sale taxes, product regulations, or disposal charges. All such concepts need to be studied further.

SIZE AND APPLICATION

Ideally the product charges should be set equal to the costs of collecting and disposing of products as waste. However, these costs are difficult (if not impossible) to establish precisely for several reasons:

(1) Solid waste management costs vary significantly across the Nation and depend on factors such as city size, geographic or topological considerations, type of disposal system used, and the efficiency and management of local operations.

(2) Solid waste management is often not carried out in an environmentally acceptable manner. For example, there are leachate and water pollution from land disposal, public health and safety impacts of open dumping and inadequate storage and collection, and aesthetic effects of litter. In this regard, solid waste management services are sometimes underpriced, and use of these costs would not provide the needed degree of internalization.

(3) There is currently no way of determining how a single product among other wastes contributes to the cost of collection and disposal.

Therefore, many simplifications, averages, and assumptions are necessary to design a practical product charge system.

In Chapter 1, it was estimated that the average national cost of collection ranges from $18 per ton to $20 per ton of solid waste, while disposal costs average about $4 per ton. In a product charge scheme these figures could be used as a reasonable measure of the management costs for mixed household and commercial wastes. Other items such as automobile hulks and discarded tires are generally collected and disposed of separately, and a special product charge would have to be established for these products.

To apply these product charges, it is necessary to establish a relationship between waste management costs and some measurable product parameter. Weight is an obvious choice for a parameter, and a uniform charge based on weight would be relatively easy to determine and apply. However, this would entail certain inequities because heavy products would be charged more than light products of the same volume. Product compacted volume is a parameter that is probably more representative of disposal costs (it is a measure of the volume of a product in a collection truck or landfill), but use of such a parameter would require analysis of the compacted volume of all products on a product-by-product basis. To avoid such administrative complexities, an index based on product weight is probably preferable. However, there would have to be special provisions for products that would be given charges out of all proportion to their disposal cost and for items the disposal of which is very costly.

For discussion purposes, consider a product charge of $20 per ton imposed at the point of sale for all products that enter the solid waste stream. If passed on to the consumer, this would represent a $0.01-per-pound charge on purchased products; such a product charge is sometimes popularly referred to as a "penny a pound."

It should be realized that not all products that flow through the economy are disposed of as solid waste. For this reason, certain products should be exempted from the charge (e.g., products that are consumed, such as fuels, tobacco, and food, and products that are dispersed, such as aerosols, detergents, and soaps). In addition, recycled materials that do not incur disposal costs should also be excluded. Such an exclusion could be implemented by providing a rebate for the use of recycled materials in production. It should be realized that this would provide a substantial incentive for the use of secondary materials ($20 per ton is much greater than any of the recycling subsidies evaluated in Chapter 3). A product charge designed in such a manner would stimulate resource recovery as well as source reduction.

It is obvious that the design and application of an equitable and effective product charge system would be a formidable task that would require considerable analysis and administration.

EFFECTIVENESS

Product charges would be expected to have an effect both at the consumer and producer levels. In the short term, producers could not fully react to the charges because of commitments to existing material supplies, equipment, and operational procedures. Therefore, initially the product charges would probably be passed on to the consumer, and the only effects would result from changes in purchasing decisions. However, in the long run, in an attempt to reduce costs, producers would be expected to institute design changes and alter material utilization patterns.

The case of packaging will be used to illustrate the effect of product charges at both levels. Packaging is the largest single product class in household and commercial solid waste. In addition, packaging has a relatively high weight to value ratio, and, therefore, a weight-based charge would be expected to be most significant.

The product sectors that have the highest ratio of packaging weight to product retail value are listed in Table 80. From these data it is apparent that the $0.01-per-pound charge would increase consumer packaging prices by a relatively small amount—less than 3 percent. Also, these four categories account for only 8 percent of all consumer expenditures. Thus, the general impact on the consumer and, hence, the expected source reduction effect at this level is expected to be small.

Manufacturers involved in the production of packaging would be expected to be most sensitive to increases in the cost of packaging caused by product charges. Table 81 shows some of the same product

TABLE 80

ESTIMATE OF THE EFFECT OF A PRODUCT CHARGE AT THE CONSUMER LEVEL FOR SELECTED CATEGORIES OF PACKAGING, 1970*

Packaged product	Packaging weight per $100 of retail sales (lb)	Product charge per $100 of retail sales† (dollars)
Soft drinks	242.70	2.43
Canned food	115.65	1.16
Beer	114.55	1.15
Prepared beverages	89.78	.90

*Source: Data provided under U.S. Environmental Protection Agency Contract No. 68-01-0791.

†Assuming a product charge of $0.01 per pound.

TABLE 81

ESTIMATE OF THE EFFECT OF A PRODUCT CHARGE AT THE PRODUCER LEVEL FOR SELECTED CATEGORIES OF PACKAGING, 1970*

Packaged product	Packaging value per $100 of retail sales (dollars)	Product charge per $100 of retail sales† (dollars)	Product charge as a percent of packaging value
Soft drinks	31.46	2.43	7.7
Canned food	23.36	1.16	5.0
Beer	18.21	1.15	6.3
Pet food	13.73	.55	4.0

*Source: Data provided under U.S. Environmental Protection Agency Contract No. 68-01-0791.

†Assuming a product charge of $0.01 per pound.

categories impacted from this viewpoint. Several conclusions can be drawn from this table. First, the charge impact is greater in terms of percent at the producer level. The soft drink sector, for example, would see its packaging costs rise by nearly 8 percent while consumers would experience only a 2-percent increase in the costs of soft drinks. Because product manufacturers are specialized purchasers of packaging, they would be expected to be very sensitive to these price changes. Producer reaction could entail a reduction in total packaging or a shift in types of packaging. It should be noted that no producer would find his packaging costs rising by more than 8 percent, and, hence, no sudden or dramatic source reduction effects would be expected.

Newspapers and magazines are other products that have high weight to value ratios and would be expected to be sensitive to product charges based on weight. Small appliances, on the other hand, have lower weight to value ratios. No analyses have yet been made on the effect of product charges on these product classes.

IMPACTS

Environment

Weight-based charges would be expected to induce some shifts toward lighter weight materials. In particular, plastic and aluminum might be substituted for glass and steel, which may increase the consumption of resources in total and increase the burden on the environment. For example, on a weight basis, production of aluminum is much more energy consumptive than production of steel. There would also be differences in air emissions and water discharges because of the use of different materials and production processes.

The refillable beverage container provides another example of this impact. Refillable glass bottles weigh nine times more than steel cans and 20 times more than aluminum cans (for 12-ounce containers). Therefore, weight-based charges would provide an incentive to shift away from the use of such bottles (even if a bottle was reused 15 times, it would be charged more than an aluminum can). However, as is discussed in Chapter 5, the refillable bottle has some preferable environmental attributes as compared to these other containers. (Its use results in less air and water pollution and lower energy consumption.)

In summary, product charges based only on solid waste management costs could clearly result in negative impacts in other environmental areas. These effects may be attenuated by the more stringent air and water pollution regulations and energy conservation initiatives that are anticipated in future years. However, a weight-based charge system in itself may have more negative than positive environmental impact.

Personal Income

An important feature of the product charge concept is its impact on various individual income levels. A study conducted by the University of Pennsylvania indicates that, with a $0.01-per-pound product charge, individuals earning over $15,000 per year would pay 0.925 percent of their incomes in addition to their current expenditures, whereas those earning under $3,000 per year would pay 1.149 percent.[1] Thus, the tax would clearly have a regressive effect.

Disbursement of Revenue Generated

A product charge of $20 per ton would have generated approximately $1.6 billion in revenue in 1972 (based on 80 million tons of product solid waste, excluding food and automobiles). These funds could be used in several ways.

One obvious option would be to distribute the funds to cities and States to pay for local solid waste management operations. If this could be accomplished effectively, it would eliminate the double tax aspect of product charges (e.g., consumers pay twice for solid waste management, through the product charge and through general taxes for local services). However, it would be difficult to assure that such funds displaced consumer expenditures at the local level. In addition, a significant portion of solid waste collection is carried out by private haulers. Providing funds only to municipal agencies would not offset these costs. Finally, federally provided funds tend to lead to overcapitalization and inefficient use of services.

A second option would be to use the funds as an incentive to implement environmentally acceptable and efficient solid waste practices. In this case, the funds would be directly returned to the States (but not necessarily earmarked for solid waste purposes), providing there are programs to close open dumps, implement Federal incinerator guidelines, regionalize planning, or institute user charges for collection and disposal. A third option would be return the funds to States, localities, or private citizens with "no strings attached" according to a revenue sharing or per-capita formula.

The manner in which the funds are disbursed does not affect product charges as source reduction or internalization measures at the producer or consumer level. However, it should be clear that there are administrative difficulties and serious policy implications with any method of fund disbursement.

SUMMARY

EPA studies in the product charge area are not yet complete. The tentative findings indicate that a product charge system is likely to have both positive and negative effects: positive as it acts to internalize solid waste costs and reduce the weight of products in waste, and negative in that it may cause undesirable material shifts, have regressive effects, and may cause administrative difficulties in the fund disbursement area.

Studies on the product charge will continue as will analysis of other product control mechanisms for internalizing solid waste management costs and reducing the generation of product waste.

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